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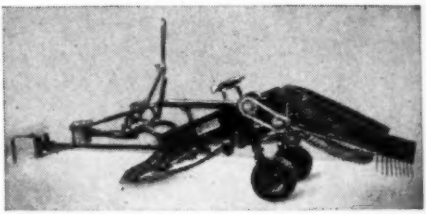

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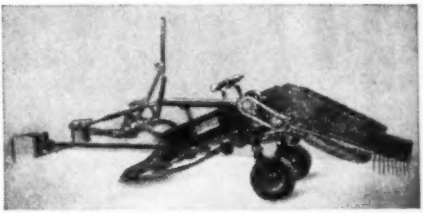

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Plenty of Potash For Good Potatoes

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If your harvest this year has been unsatisfactory, you will wish to start checking up now on your soils and fertilization practices to see if you are using enough potash to get the larger yields and greater percentage of No. 1's which this necessary plant food insures. For a good crop of first grade potatoes, soil and fertilizer must supply at least 200 lbs. of available potash per acre. Your county agent or experiment station will help you check soils and fertilizer practices. Your fertilizer dealer will tell you how little it costs to apply enough potash.

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THE RELATION OF THE CALCIUM ION TO THE SLOUGHING OF POTATOES[1]

W. E. PYKE AND GESTUR JOHNSON

Colorado Agricultural Experiment Station, Fort Collins, Colo.

Although many methods for the cooking of potatoes are known, the relatively recent survey by Bakken (1) shows that boiling is still, by far, the most prevalent method used. Unfortunately most varieties of potatoes have a considerable tendency to "boil to pieces" or slough. The work of Rathsack (2) showed that turgid or firm unprepared tubers had a much greater tendency to burst and slough than wilted or soft tubers. Barmore (3) followed the tendency of diced potatoes to slough. He used tubers which had been stored for various periods of time under relatively warm conditions. He then concluded that storage of potatoes in a warm place for a period of time will bring about a decrease in the amount of sloughing.

Investigations on the culinary quality of potatoes, conducted at this station for a period of years have shown that the tendency of potatoes to boil to pieces may prove very troublesome, and may be responsible for a considerable economic loss to the user. Some of the most desirable varieties from the standpoint of mealiness, texture of product, color and flavor have this undesirable characteristic.

That the cementing material for the cells of the potato was composed of pectic substances was shown by Carre and Horne (4) in 1927. Dastur and Agnihotri (5) published the results of an extensive study of the changes of pectic substances in potato tubers at different stages of growth and in storage. Observations of the authors of changes occurring during the boiling of potatoes indicated that sloughing was caused primarily by the failure of the cell cementing materials to continue to function, as such, in hot water. The suggestion of Rathsack that the turgidity of the tubers was related to boiling to pieces was seen to be a contributing factor. Hard turgid

[1]Received March, 1939.

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pieces of potato tubers would fracture much more often and to a greater extent. These fractures would permit the ready penetration of boiling water to a greatly increased potato surface and should speed up markedly the dissolving of pectic acid and protopectin, both of which go into solution in hot water. As a result of these observations it was believed that an investigation of this mechanism of the sloughing process might prove enlightening.

The potato is known to be one of the richest food sources of minerals and probably the least expensive source of most of the other nutritional essentials of our diet. Although raw potatoes contain about 1 per cent mineral matter, a large percentage of this (nearly 50 per cent) may be lost in the cooking water when they are boiled. The calcium in which we are interested diffuses out with the other elements during the cooking process. Recently Hoygaard and Rasmussen (6) have shown that boiling potatoes in 1 per cent salt solution inhibits the destruction of Vitamin C (ascorbic acid) so that considerably more vitamin is retained in the potato when it is cooked in salted water.

Now soluble pectin readily dissolves in cold water and protopectin becomes soluble rapidly in water at 85° C (185° F°). These pectic substances form an insoluble jelly-like substance in the presence of appreciable amounts of calcium ion. The calcium content of the potato decreases continuously during boiling in pure water or more rapidly still in salt water so that these cementing materials are rapidly dissolved and segments of potato tissue break away. If one should add to the table salt solution a sufficient concentration of calcium salt to maintain the calcium content of the potato at its original value the cementing pectins should be rendered insoluble and sloughing should become negligible.

EXPERIMENTAL METHODS

The Horticulture Section and the Chemistry Section are co-operating with the Home Economics Section on the potato project. The Russet Burbank potatoes grown as part of the 1938 experimental program of the Colorado station on the college farm at Avon were supplied by Carl H. Metzger of the Horticulture Section.

The potatoes were pared and prepared for boiling in two ways. One sample was diced. The second sample was composed of pared tubers that had been quartered or halved. After draining and drying until the layer of adhering water had evaporated the samples were weighed. They were then placed in ordinary fry baskets of ¼ inch wire mesh and immersed in kettles containing the boiling solution to

be used and covered during the cooking period. Approximately 150-gram samples of diced potatoes (cubes 2 cm. on a side) were boiled for 30 minutes. The pan was then removed from the fire, the basket raised and allowed to drain five minutes. The solution was then filtered, and the residue dried and weighed. The dry weight of this residue divided by the weight of the fresh sample times 100 is taken as the measure of sloughing. This measure of sloughing was used

FIG. 1.—*Composition of Water in Which Potatoes Were Boiled*

Photo No.	Gms. Wt. of Water	Gms. Wt. Calcium Chloride	Gms. Wt. Sodium Chloride
1	1500	7.5	7.5
2	1500	5.0	10.0
3	1500	10.0	5.0
4	1500	3.75	3.75
5	1500	2.0	2.0
6	1500	1.0	1.0
7	1500	1.0	14.0
8	1500	0	0

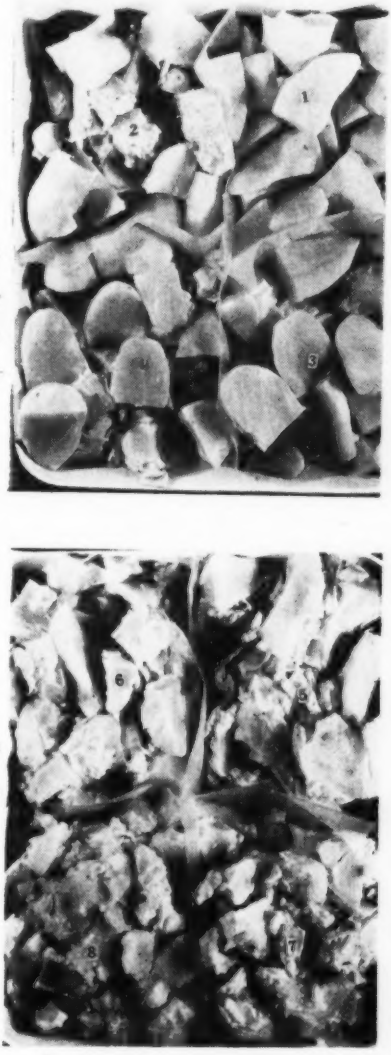


FIG. 1—SLOUGHING WAS LARGE IN No. 8. SLIGHT IN No. 7; AND PRACTICALLY *Nil* IN THE OTHER SAMPLES. THE VARIATION IN FRACTURING IS APPARENT

TABLE 1.—*Diced potatoes*

Composition of Boiling Water:	Sample Number 1	2	3	4	5	6	7
(Gms. weight of 2½ per cent calcium chloride)	0	45	90	135	180	0	360
(Gms. weight of 2½ per cent sodium chloride)	180	135	90	45	0	0	0
(Gms. weight water)	720	720	720	720	720	900	540
Weight of diced potatoes	156.6	153.7	155.5	155.7	155.0	154.1	155.1
Sloughing (moderate)	2.9	0.55	0.14	0.60	0.14	2.5	0.09
Sloughing (bad)	4.3	1.0	1.6	1.4	0.12	3.8	0.16
Per cent water in cooked potatoes (Moderate slougher)	79.8	78.6	78.3	78.1	78.9	81.8	76.8

(The water content of the raw cubes was 75.5%)

Note: The total salinity in this series with the exception of Sample No. 7 is 0.5 per cent. In No. 7 it is 1 per cent. 0.5 per cent salt is not enough to flavor the potatoes properly. 1 per cent serves very well.

TABLE 2.—*Quartered and halved potatoes*

Composition of Boiling Water	Sample Number 1	2	3	4	5
Gms. weight of calcium chloride	0	1	2	7.5	0
Gms. weight of sodium chloride	0	14	13	7.5	15
Gms. weight of water	1500	1500	1500	1500	0
Gms. weight 0.143% calcium sulfate (approximately saturated solution)	0	0	0	0	1500
Percentage salts in cooking water	0	1	1	1	1.14
Gms. weight of potatoes	1008	1002	1008	1010	1001
Watts required to beat potatoes					
1st 30 seconds (no water)	3.40	3.40	3.40	3.35	3.40
2d 30 " (50 cc. potato water)	3.62	3.70	3.70	3.62	3.72
3d 30 " (100 cc. " ")	3.44	3.63	3.77	3.69	3.77
4th 30 " (150 cc. " ")	3.37	3.48	3.65	3.73	3.69
5th 30 " (200 cc. " ")	3.25	3.38	3.44	3.78	3.58
6th 30 " (250 cc. " ")	3.18	3.30	3.39	3.64	3.43
7th 30 " (300 cc. " ")	...	3.15	3.28	3.56	3.37
8th 30 " (350 cc. " ")	...	...	3.19	3.43	3.18
9th 30 " (400 cc. " ")	...	...	...	3.27	...
10th 30 " (450 cc. " ")	...	...	...	3.20	...

by Barmore (3). The quartered and halved potatoes were placed in the 3-quart bowl of a Hobart Mixer and beaten with the paddle at 30 second intervals. Fifty cc. increments of the "potato water" in which the sample had been boiled were added to the sample after each period of beating, and the beating process was repeated again until the drop in the power required leveled off rapidly. A summary of the results of part of these investigations is given in tables 1 and 2.

Only a rather small portion of our data can be presented here. They show quite definitely that sloughing may be controlled by the presence of sufficient calcium salt in the cooking water to maintain or slightly raise the calcium content of the potato. Confirmatory experiments with Irish Cobblers and Brown Beauties gave similar results.

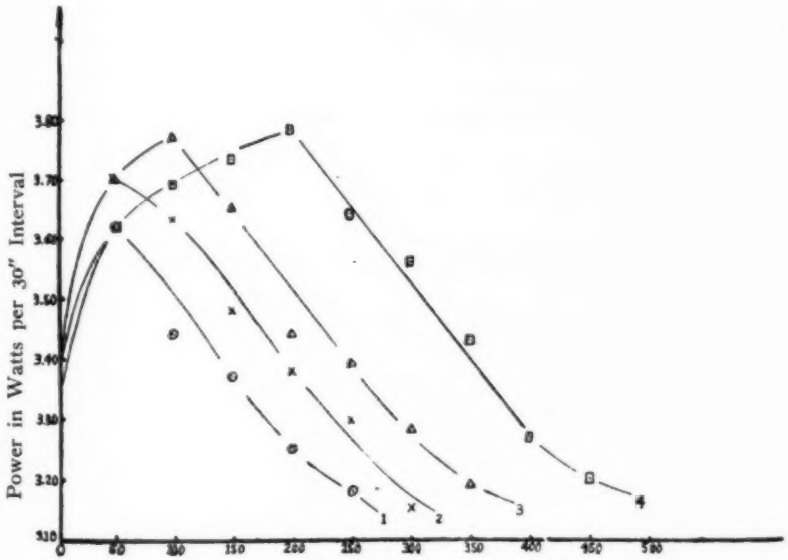
The correlation coefficient for the power used in beating (mashing) the boiled potatoes against sloughing for all experimental growing treatments for the season 1938 was -0.50. The significance of this value lies between the 5 per cent point and the 1 per cent point. The dates of planting of the potatoes in these samples varied. Altogether, samples representing 16 different field treatments were examined. Two field treatments yielded potatoes very much at variance to the other treatments and lowered the overall correlation coefficient markedly.

Observations on the cooked potatoes indicated that cracking or fracturing of the pieces becomes increasingly less as the calcium content of the cooking water is increased. Wiegand, Norton and Peutzer (7) have recently reported very satisfactory control of cracking in the brining of sweet cherries through the use of calcium carbonate. Since this was introduced into SO_2 brine which was quite acid, corresponding to the recommendations of Cruess (8), the carbonate was destroyed and the calcium ion passed into solution. Stiles and Jorgensen (9) had shown in 1917 that potato tubers and carrot roots swelled less in hard water (containing calcium salts and others) than they did in distilled water. That the imbibition of water varied considerably in our samples is shown in table 1. However, any reference to osmotic tendencies would be out of place since even superficial observation shows that the surface membranes of the potato are very different in the samples where the calcium ion is present in the solution by experimental addition from those where it has not been added. The relation of the power required to beat the cooked potato is plotted against its water holding capacity in figure 2. These curves represent the data of samples 1, 2, 3 and 4, in table 2. The texture and consistency of the mashed product was the same at the terminal shown for each curve. The product at this point contains more liquid than would be desira-

ble in mashed potatoes. Each sample, when mashed, was free from lumps. A considerable elasticity was shown in the boiled potatoes of sample 4, table 2 and samples 4, 5 and 7 of table 1. Such properties may be desirable in diced potatoes to be used for salad purposes, where considerable abuse of the cubes is to be expected. Usually such characteristics would not be desired. Potatoes with extremely high sloughing properties were so highly hydrated when cooked in water alone, that no hump in power was shown upon the addition of the first increment of potato water. Table salt increased this tendency. The power required to drive the mixer for 30 seconds when empty was 2.81± 0.03 watts. The values given in table 2 have about the same degree of accuracy.

Discussion

Plant breeding is necessarily a slow process. One to two generations of potatoes are all that are feasible, annually. The isolation of a strain of plants or the development of a variety with certain desirable features too often includes other characteristics that are definitely undesirable. A quite different approach to the economic utilization of crop and food plants is that of the chemical industry. Raw ma-



Cu. Cms. of Potato Water Added to Sample

Fig. 2.—Variation in Capacity of Boiled Potatoes to Take up Liquid.

terials, intermediates and finished products are used because of certain properties they display. The manner in which they are used and the type of treatment they receive depend upon the characteristics of the material being utilized. Since the development of the perfect potato for every use to which man cares to put it is a long way off, it seems a more reasonable approach for man to know his potatoes so well, that he is able to make them behave as he desires by a variation in methods of handling and treatment. In this way he may be able to take complete advantage of the contributions they may make toward his comfort, happiness and welfare. Intelligent use can come only after the characteristics of a substance are understood fully.

From the data given, it is evident when approximately 12.5 per cent (1/8) of the salt used in the water in which potatoes are boiled is a soluble calcium salt, satisfactory control of sloughing may be obtained. The number of fractures caused by swelling is decreased considerably with this concentration of calcium ion present. The total salinity of the cooking water should be about 1 per cent.

The choice of the calcium salt to be used will be influenced considerably by their properties. Some of the most readily available calcium salts are too hygroscopic to be advisable under many climatic conditions unless used in solution. Calcium chloride is the most common representative of this group. Many other calcium salts are too insoluble to be practical. Calcium sulfate is a border line case. A saturated solution of calcium sulfate (artificial hard water) serves admirably in the control of sloughing. This saturated solution should be salted in the usual manner when used. In Colorado and many other states deposits of hydrated calcium sulfate (gypsum, alabaster, selenite, satin-spar) occur in large quantities. They may be used to make a readily available "hard water" by pounding up some of the mineral until it is powdered, placing a handful in a gallon jug, and shaking with water. After standing for a day the water is practically saturated with calcium sulfate.

An additional calcium salt should be mentioned because of its ready solubility and non-poisonous nature. It is not hygroscopic and shows little tendency to lump when mixed with table salt. This compound, calcium sulfamate, is a new industrial chemical that has been made available in quantity at moderate prices only recently.* The results produced by this salt are comparable in every respect to those produced by calcium chloride and calcium sulfate. It has the added advantage that it may be mixed with table salt in the proper proportions

and added in the solid form to the cooking water, when the water is salted before the potatoes are boiled.

It is true that in larger markets several varieties of potatoes are available, so the purchaser may choose the variety best adapted to the intended use. More than one variety of potatoes may be stocked by the housewife under such conditions. It is often, by no means, convenient for the consumer to store more than one variety of this desirable vegetable. It may be more convenient to maintain a small supply of a soluble calcium salt in the home, and control the cooking process so that one variety of potato will behave as desired, when cooked in the various ways the consumer wishes. The choice lies with the consumer.

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RESISTANCE IN WILD POTATOES TO ATTACK BY THE POTATO LEAFHOPPER AND THE POTATO FLEA BEETLE[1]

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The purpose of this investigation was to determine whether characters of entomological importance are to be found in the species of *Solanum* related to the potato. Much work of a horticultural and pathological nature has been done with the plants of this group and a

[1]The author is indebted to Prof. Donald Reddick of Cornell University for seed stocks of the several species.

fund of such information is available concerning them. The entomological aspects of the matter have been generally neglected.

Studies conducted by the writer during the past several years show that characters of entomological importance exist in some species of wild *Solanum*. These characters would be especially valuable if they could be incorporated in the best of the commercial varieties of potatoes. The data obtained in these experiments are concerned with the potato leafhopper, *Empoasca fabae* Harris, and the potato flea beetle, *Epitrix cucumeris* Linn.

The species of wild potatoes used were grown in the field under conditions of natural infestation. Each of the sorts was planted in plots 1 x 5 hills in size, replicated 5 times in randomized blocks.

The method used in determining leafhopper populations was that of counting the nymphs on 40 leaves selected at random from each plot. Nymphs seldom leave the plant and may be counted readily upon an individual leaf. The adult leafhoppers, however, are very active and move freely from plant to plant. Therefore, the nymphal count was considered the better index of relative populations.

Flea beetle populations were not determined by actual count of the

TABLE 1.—*Leafhopper populations and amount of feeding by the adult flea beetle on twelve species of Solanum, McGuffey, Ohio*

Species of *Solanum*	Year	Number of Leafhopper Nymphs per 40 Leaves	Number of Adult Flea Beetle Feeding Punctures per Leaf Disc, 1.25 Cm. in Diameter
S. tuberosum (Irish Cobbler)	1936	106.0	13.8
S. polyadenium	"	0.6	0.0
Irish Cobbler	1937	303.2	10.6
S. polyadenium	"	0.0	0.0
Irish Cobbler	1938	49.8	97.0
S. bulbocastanum	"	27.8	2.8
S. neoantipoviczii	"	20.0	9.2
S. neoantipoviczii var. Reddick	"	13.4	13.6
S. fendlerii	"	6.0	9.8
S. demissum, var. 1	"	4.2	18.0
S. verrucosum	"	2.2	11.8
S. demissum, var. 2.	"	1.4	10.8
S. chacoense	"	0.2	44.4
S. commersonii	"	0.2	42.2
S. jamesii	"	0.2	17.5
S. caldasii	"	0.0	48.4
S. polyadenium	"	0.0	0.2

Figures are the means of 5 replications.

insects. The number of feeding punctures in a unit area of leaf surface was considered a reliable index to the size of the adult population. A sample of 10 leaves was selected at random from each plot and the feeding punctures counted in an area 1.25 centimeters in diameter taken randomly from each leaf.

Tests were conducted in the laboratory in an effort to determine whether the very young leafhopper nymphs were able to feed and grow to maturity on several of the species which the field records indicated were resistant. The leaves of such plants were placed in 4-inch petri dishes into which 20 nymphs were introduced. Fresh food was provided daily. After the leaves had been exposed to the insects for a given length of time, the amount of feeding was determined by noting the rate of mortality and the number of nymphs which were successful in reaching the adult stage. Similar tests were conducted with the flea beetle in which the number of leaf punctures was considered indicative of the amount of feeding by the adults.

A number of species in the field-exposure tests showed very low leafhopper nymphal populations as indicated by the data recorded in table 1. *Solanum chacoense, S. caldasii. S. commersonii,* and *S. polyadenium* were very lightly populated. The last named species appears to be highly resistant, if not immune, to leafhopper attack. The few nymphs which have been found upon it were of the fourth and fifth instars. The writer never observed a first instar nymph. This indicates that any population which occurred on this species probably migrated from adjacent susceptible varieties. Results obtained in laboratory feeding tests, which are summarized in table 2, support this contention.

TABLE 2.—*Rate of mortality of leafhopper nymphs on four species of Solanum in laboratory feeding tests,* 1938

Species of *Solanum*	No. Nymphs Introduced	After 10 Days' Exposure			Per Cent Mortality
		No. Nymphs Alive	No. Nymphs Dead	No. Nymphs Transforming to Adults	
Irish Cobbler	20	15.0	0.6	4.4	3.0
S. demissum	20	6.0	12.6	1.4	63.0
S. caldasii	20	2.0	17.6	0.4	88.0
S. polyadenium	20	0.0	20.0	0.0	100.0

Figures are the means of 5 replications.

Further analysis of the data set forth in table 1 shows that *S. bulbocastanum* and *S. polyadenium* were resistant to attack by the potato flea beetle. *S. polyadenium* was very lightly fed upon by the adults and such feeding as did occur was confined to the lower, mature leaves. The foliage of this species has a very disagreeable odor due to an oil or ester on the upper and lower leaf surfaces and also on the stem parts. The odor is very strong on the younger leaves but much less pronounced on the lower, mature ones. This odor may be the restricting factor for the slight amount of feeding on the younger foliage of this species. Some evidence to support this hypothesis was found when adult beetles confined in laboratory cages fed more readily upon younger leaves washed with soap and water to remove the oil than on the mature leaves which normally are the more attractive. The data on this point are presented in table 3.

TABLE 3.—*Amount of feeding by adult flea beetle on two species of Solanum in laboratory cages,* 1938

Species of *Solanum*	No. of Adult Feeding Punctures per Leaf Disc, 1.25 Cm. in Diameter
Irish Cobbler leaves	456.4
S. polyadenium, immature leaves	28.9
S. polyadenium, mature leaves	100.9
S. polyadenium, washed leaves	132.8

Figures are the means of 15 replications.

SUMMARY

Solanum polyadenium was found to be highly resistant, if not immune, to attack by the potato leafhopper. Three closely related species, *S. chacoense, S. commersonii,* and *S. caldasii* also were highly resistant to the leafhopper.

S. bulbocastanum showed fair resistance to flea beetle attack. *S. polyadenium* was highly immune to attack. Only slight feeding by the adult flea beetles occurred on this species.

CERTAIN ASPECTS OF THE ALABAMA FIELD TESTS OF SEED POTATOES AS A REQUISITE FOR CERTIFICATION

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If there stands one single proved fact in experimental agriculture it is the superiority of certified over non-certified seed potatoes. As early as 1924 Moore (1), citing 11,627 tests which had been conducted in the United States and Canada, showed an average advantage in yield of 46 bushels per acre for the certified seed. Data submitted by Tucker (2), giving by three-year periods the amount of various diseases in 117,474 fields inspected under the Canadian certification program, showed within a period of fifteen years a decrease in blackleg from .67 to .14 per cent; a decrease in leaf-roll from .34 to .16; and a decrease in mosaic from 2.39 to .74 per cent. Such inclusive records offer conclusive proof of the value of certification. In the areas producing the seed, certification has offered a means by which states with better programs could move forward in a competitive bid for business by producing better seed; in consuming states it has meant better yields because of better seed. Potato seed improvement and certification in seed-producing states have made definite contributions to the growers in the consuming southern states, and may no statement or inference be taken to minimize the recognized value of this service. When, however, experimental records in Alabama on 262 lots of certified seed in the same year showed 14 lots yielding 150 bushels per acre of potatoes less than 19 others, or 46 lots yielding 100 bushels less per acre than 57 others, then it may be a mistake to assume that all has been done that might be done for the southern potato grower by supplying him with seed potatoes that bear a certification tag of the producing state which is but evidence, primarily, of the fact that those potatoes have not exceeded certain disease limits when grown in the seed-producing states and when stored and handled according to the recommended methods for the section.

Alabama and other southern potato-growing states produce potatoes for table use. The South is not a seed-producing section. Only bags of potatoes can be converted into financial returns. Good seed for the South are those that produce high yields of good table quality potatoes. So long as differences of 150, or 125, or even 50 bushels per acre are obtained in the yield of certified lots of the same variety of potatoes when they are grown experimentally in the South under the

same conditions as the southern grower must grow them, then existing certification programs in seed-producing states are failing to reach and reckon with certain factors that have a profound influence on the yielding ability of seed in the South. These factors may lie outside the field of disease; they may fall in the field of physiology or heredity. It is not inconceivable, however, to believe that the objective of certification might become that of producing good seed rather than that of producing seed bearing low amounts of disease.

Alabama Seed Potato Regulations

It was with the idea that the original objectives of certification might possibly be too limited to provide the best seed for the South that Alabama attempted a new approach to the problem. According to regulations adopted in 1936, Alabama required that each lot of seed to be sold in Alabama under an Alabama certification tag must be placed on test in Alabama the year before it is to be sold and must produce, when tested, 75 per cent of the yield of the 10 leading strains. Disease limits were also established. Seed lots meeting the requirments qualified for the use of an Alabama certification tag; other lots were required to carry a non-certification tag.*

Alabama does not discredit certification programs in other states; as a matter of fact, the Alabama regulations specify that seed potatoes, before they can qualify for Alabama certification, must also qualify for certification in the state of origin. The use of the Alabama certification tags by growers in seed-producing states on only those lots tested depends almost entirely on the cooperation of seed certification officials of the seed-producing states.

Since Alabama regulations differ from all other southern regulations, in that a southern field test is a necessary part of the requirements for certification, and since the yield requirements is so different from the requirement of any state in America, the discussion which follows will be devoted largely to a consideration of the yield phase of the regulations.

Justification of the Yield Requirements in Southern Field Trials for the Certification of Seed Potatoes in Alabama

The use of a yield requirement for seed certification is so new that its value will have to be proved before it can be generally accepted in certification programs. Certification regulations have for so long

*Alabama has temporarily suspended certain of its 1936 regulations.

been based on disease limits that any departure from this approach is viewed with apprehension. The truth of this assertion rests not on the abundance of accurate data, proving the value of the old methods, but on the newness of the different approach. The old established approach, incidentally, badly needs supporting proof of its value to the southern grower, and it may be in order to suggest that proof of the value of the new approach may be forthcoming even sooner than proof of the value of the old, for already Alabama has three years' records with a fourth year just ahead to serve as a basis for the study of the new approach; whereas, the American Potato Association has just recently asked Federal aid to study the degree to which yields are affected by the several seed-borne diseases. It may also be advisable to suggest that nothing short of an established relationship between disease readings in the seed-producing states and the yield of potatoes in the South can supply the needed proof. At best this can be only indirect proof and, then, for only one of several factors that may affect the yield of southern potatoes. The yield method of determining the value of a given lot of seed supplies the one measure of performance which takes into account the sum effect of all operative causes which affect productivity. The result which is obtained offers a direct means and the only means of measuring in dollars the value of seed. The yield method, admittedly, does not determine the causes of differences or quantitatively measure the relative influence of the several factors responsible for high or low yields—it doesn't need to—it is sufficient to know that certain lots of seed produce yields ranging from 50 to 100. 150, or 200 bushels less than other lots when grown under the same experimental conditions to know that these seed lots are inferior for the purpose used.

Sample and Plot Technique in Alabama Field Trial

The individual seed lots have been gathered each year by the seed-certification officials in the producing states by taking a random sample usually from the storage bins. In most states the various lots have then been carried to a central storage point, stored under the same condition, and later shipped in one car to South Alabama where the field test is conducted. Seed pieces have been cut, at the same time, to a uniform weight, taking one seed piece from each tuber. There have been three replications, each single replication consisting of a single row planted to 97 seed pieces; each lot therefore has had 291 seed pieces on test representing the same number of tubers. In the field seed pieces have been spaced exactly 16 inches apart in 3-foot rows. An application of 1500

pounds of a 4-10-7 fertilizer per acre has been used. The fertilizer has been weighed separately for each row. Data on diseases were taken twice during the growing season. Yield data have been based on United States standard grades.

Results of Yield Records in Alabama Field Trials

In table 1 is given the number of lots that have fallen in each yield class for each of the three years. Each lot reported represents the seed certified in the seed-producing state. A striking similarity exists in the distribution of yield classes for each of the three years. The spread in yield has been greater in years of high average yield. In 1936, the spread in yield classes was 250 bushels; in 1937, the spread was 175 bushels and in 1938, 225 bushels per acre. A few of the striking facts of the table might be stated. In 1936 there were 172 lots tested. Three lots differed from 2 others by 200 bushels per acre; 9 differed from 11 others by 150 bushels or more; 26 differed from 31 others by 100 bushels or more; 49 differed from 65 others by 50 bushels or more. In 1937 from a total of 138 lots tabulated, 6 differed from 7 others by 150 bushels per acre; 13 differed from 38 others by 100 bushels or

Table 1.—*Number of certified seed lots* falling in different classes according to yield in the Alabama field tests.*

Yield Class Bushels per Acre	1936		1937		1938		Total for 3 Years	
	Number Lots		Number Lots		Number Lots		Number Lots	
	Each Class	Accum.	Each Class	Accum.	Each Class	Accum.	Each Class	Accum.
50	1	1	2	2	1	1	4	4
75	1	2	4	6	1	2	6	10
100	1	3	7	13	12	14	20	30
125	6	9	37	50	32	46	75	105
150	17	26	21	71	60	106	98	203
175	23	49	20	67	45	151	97	300
						156		
200	58	107	31	38	54	111	143	272
		123						
225	34	65	7	7	38	57	79	129
250	20	31			17	19	37	50
275	9	11			2	2	11	13
300	2	2					2	2

*Only seed potatoes certified in the state of origin were included in the tabulation.

more; 50 differed from 67 others by 50 bushels or more. In 1938 from a total of 262 lots tabulated, 2 differed from 2 others by 200 bushels per acre; 14 differed from 19 others by 150 bushels or more; 47 differed from 57 others by 100 bushels or more; and 106 differed from 111 others by 50 bushels or more.

To express in a practical way the meaning of these differences it would be explained that in the same year, though they were planted on the same soil, with the same quantity of seed to an acre, though the several lots were all certified according to certification requirements of the seed-producing states, and even though they were fertilized and cultivated alike, certain lots produced from 50 to 250 bushels of potatoes less per acre than other lots.

Significance of the Differences in Yield to Alabama Growers

The yields in 1938 will serve to illustrate the practical signifiance of yield differences to southern growers. The average yield of the 22 lots producing 125 bushels or less per acre was 104 bushels per acre, and of the 24 lots producing 225 bushels or more per acre, 239 bushels per acre. This is a difference in yield of 135 bushels per acre. This difference is real; it does not have to be converted into other figures before its practical significance to a grower may be understood. This difference may be expressed in dollars lost because of the use of seed lots which have produced less than other seed lots have produced. If we assume a value of $1.00 per bushel for the potatoes produced, the southern grower would have lost $135 per acre by the use of lots in the lower-yielding group as compared with the use of lots in the higher-yielding group. If the seed in the lower-yielding group had been donated and if the seed in the higher-yielding group had cost $1.50 per bushel the southern grower would still have had an advantage of $117 per acre for using seed lots in the higher-yielding group.

Such differences cannot be ignored. Differences of opinions regarding the cause for these differences in yield may exist, but to ignore these differences is to close one's eyes to losses that mean multiplied hundreds of thousands of dollars to the southern grower; to him, these losses are no less real because they are caused by factors not detected by the existing systems of measuring the value of seed potatoes.

Experimental Significance of the Differences

An indication of the reliability of the results might be obtained by an analysis of records from 78 lots of Triumph seed collected from one state in 1938. The spread in yield of these seed lots was 69 bushels per acre or the yields ranged from 142 to 211 bushels per acre. The

mean for the entire group was 176.5 bushels per acre with a standard error for the experiment of 7.99 bushels per acre. According to tables given by Fisher (3) for values of "t" at the 5 per cent level, a difference of only 22.35 bushels per acre was necessary for significance.

Grouping of the lots of the aforementioned sample into yield classes with 25-bushels-per-acre intervals gives 12 lots differing in yield by 25 bushels from 46 other lots, 12 differing by 50 bushels from 20 other lots, and 46 differing by 25 bushels from 20 other lots.

Significance of the Yield Records in Certification Programs

If it could be definitely and conclusively proved that the yield of a given lot of potatoes on test one year gave unfailing indication of its productivity the following year, then there could never be just and fair reasons for objections on the part of seed-producing states to yield tests by seed-consuming states and the use of the results as a basis for certification. The major concern of the southern grower is a large yield of high quality potatoes. If a given lot of seed does not produce yield so high as other lots in the South, it is an inferior seed under the circumstances for the purpose used. Alabama yield tests have conclusively proved that large differences in yield are obtained year after year between different lots of certified seed grown under conditions as nearly alike as can be experimentally supplied. Since it is now known that differences do occur and that these differences are extremely large in a considerable portion of the total lots tested, then it becomes the duty of those responsible for the welfare of potato growers in both producing and consuming states to determine the causes of low production, and it would be an extremely narrow view of the problem at hand if we continued to think of disease as being the only factor which plays a part in determining the value of seed. It is difficult to admit that a procedure which has been followed for years might not be adequate to obtain the objectives of a program; but such may be true. Certainly, since there are reasons to believe the old procedure may have certain shortcomings, the responsible agricultural leaders would be remiss to their duties if they did not examine critically and with open minds the adequacy of the long-established procedure in meeting the broad objectives of better seed for southern planting.

General Consideration of the Field Trials

The discussion so far has dealt largely with yield phases of the Alabama regulations. It may be well to look at the result of the broader certification program. In 1936 there were in the Alabama field trials

172 lots of potatoes certified according to the requirements of the seed-producing states. Of this number 75 failed to qualify for certification in Alabama. In 1937, of 138 lots of potatoes on trial, 62 failed to qualify. In 1938, of 262 lots on trial, 103 failed to qualify. Yields below the requirements were responsible for 14 rejections in 1936; 42 in 1937; and 53 rejections in 1938. There were 12 lots in 1936; 9 in 1937; and 15 in 1938 that failed to qualify both because of low yields and excessive amounts of disease. Diseases in excess of the tolerance limits were responsible for the other rejections. The detail records indicate that diseases have been responsible for only a small part of the great differences found in the yields of various lots.

Conclusion

The Alabama certification program is an experiment; southern, eastern, and western states alike should look with keen interest to the results of the tests. Certainly if we are fair minded we shall concede that nothing is gained by discrediting or by upholding the procedure from a selfish viewpoint; the only effort worthy of those in public service is to discover the true value of the program. If it is of no value, no state would profit more than Alabama from this knowledge, for Alabama has no reason to continue a program the results of which cannot be converted into profit for its people.

If, however, continued critical study of the value of the Alabama program shows that it is rendering a definite service to the growers of Alabama, one might venture to suggest that the time may not be far distant when southern states might have two or more carefully chosen locations in the South serving as southern test plots and supported by the several southern states according to their respective potato acreages. The behavior of lots in these trials would serve as a final criterion for certification of seed for southern plantings. Such an arrangement would permit uniform certification regulations for all southern states, and the certification would be based on performance in the South as well as on disease records in the producing states.

Serving equally as important a purpose as southern yields in determining the value of seed lots may be information on the relationship of such factors as fertility levels, cultural practices, growing conditions, maturity of tubers at digging time, and storage conditions of the seed lots in producing states to yield of potatoes in the South. With this information growers may know what factors, other than disease, are responsible for poor seed. The matter of producing good seed would then be less of a gamble. The value of the Alabama field trials to

growers in seed-producing states has already been established and generally recognized by both the certification authorities and the growers themselves.

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FERTILIZATION AND EARLY EMBRYO DEVELOPMENT IN THE POTATO

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Many commercial varieties of the potato, *Solanum tuberosum* L., produce few, if any, fruits under ordinary field conditions. Naturally the potato breeder is seriously hampered by the difficulty in obtaining viable seed. Morphological studies of flower and seed development in the potato are of value, therefore, in furnishing a basis for the study of the effects of various genetic and environmental influences on the production of flowers and fruits.

Nannetti, (7) working with *Solanum muricatum* failed to discover a tetrad of megaspores. Young (12) concluded that in the potato, the megaspore develops directly from the archesporial cell, and no linear row of four megaspores is developed. However, Bhaduri (1), working with *S. melongena,* and Krüger (6), working with *S. nigrum, S. tubingense,* and *S. proteus,* found the normal linear tetrad of megaspores. In a more recent study Rees-Leonard (8) showed clearly that in *S. tuberosum,* a linear row of four megaspores is formed, the chalazal megaspore functioning in the development of a typical 8-nucleate embryo sac. She also found that changes involving degeneration within the ovule may occur at any time during megasporogenesis and during the development of the megagametophyte, and that degeneration of mature megagametophytes occurs frequently.

Earlier workers confined their attention chiefly to the development

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of the embryo sac prior to the time of fertilization. The present study deals more particularly with fertilization and very early embryo development.

Materials and Methods

The self-fertile variety, Earlaine, was used in this study. Material was collected in the field at Presque Isle, Maine, in the summer of 1938. During the period when collections were made, the weather was for the most part cloudy, with frequent showers. However, the fifth, seventh, eighth, and tenth days after pollination, were clear. The mean temperature during this period was approximately 64° F. with a minimum of 50° F. and a minimum of 81° F.

Material was fixed in either formalin-acetic-alcohol, consisting of 10 c.c. of formalin, 5 c.c. of glacial acetic acid, 90 c.c. of 70 per cent alcohol, or in chrom-acetic-formalin. The latter fixative was composed of equal parts of solution A, consisting of 1 gram of chromic acid and 7 c.c of acetic acid to 92 c.c of distilled water and solution B, consisting of 30 c.c. of formalin to 70 c.c of distilled water. The two solutions were mixed just before using. To facilitate the rapid penetration of the fixing agent the pistils were first dissected out, and the styles and outer ovary wall removed. Before using the chrom-acetic-formalin fixative, the material was dropped for a few seconds into Carnoy's fixative, then transferred, since it otherwise tended to float on the surface of the fixative. After 12-24 hours the material was washed, dehydrated in alcohol, cleared in chloroform and embedded in paraffin.

Transverse and longitudinal sections were cut at thicknesses varying from 8 microns to 15 microns. Slides were stained in Heidenhain's iron alum haematoxylin and in Delafield's haematoxylin. Drawings were made with the aid of a camera lucida.

Observations and Discussion

The reduction divisions in the anther precede those in the ovule, as tetrads of microspores have been observed in flowers in which the megaspore mother cells of the ovules have not yet begun to divide. Young pollen grains are already formed by the time the megagametophyte has completed its development.

The mature megagametophyte is 7-celled (Fig. 1). The three antipodal cells degenerate early, sometimes completely disappearing before the fusion of the polar nuclei, as previously pointed out by Young (12) and Rees-Leonard (8). The two synergids elongate, the micro-

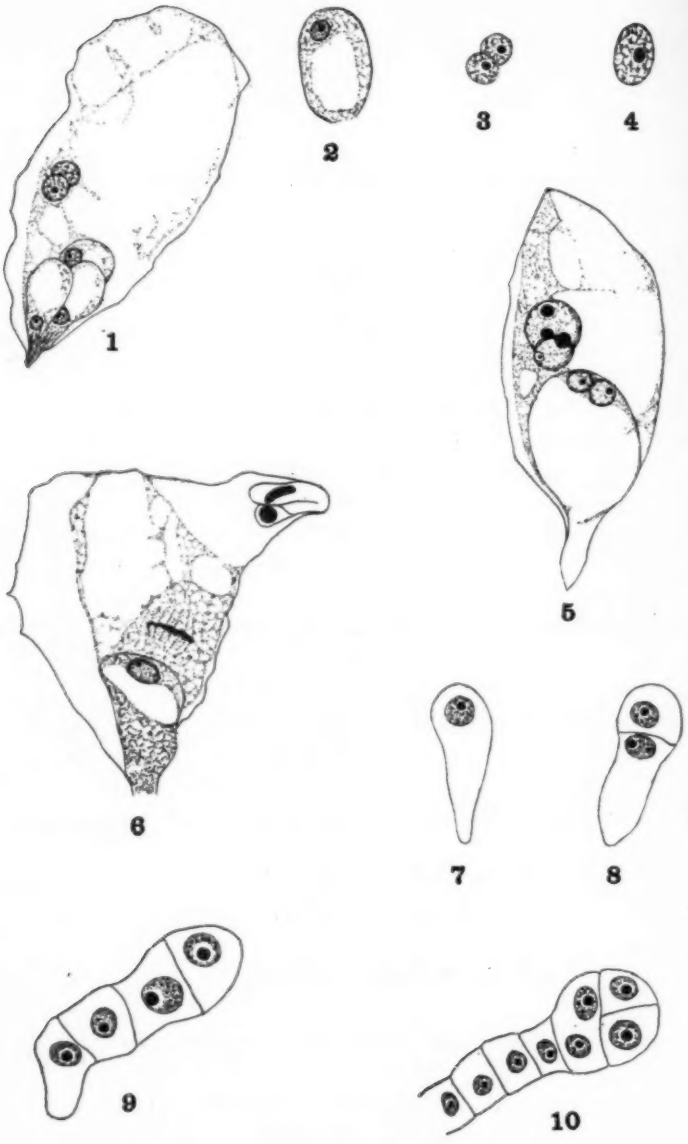

Fig. 1. Embryo sac before fertilization. Fig. 2. Egg before fertilization. Fig. 3. Polar nuclei before fusion. Fig. 4. Fusion nucleus. Fig. 5. Embryo sac during fertilization. Fig. 6. Embryo sac, showing endosperm division. Fig. 7. Zygote. Fig. 8. Two-celled embryo. Fig. 9. Four-celled embryo Fig. 10. Eight-celled embryo.

All figures at magnification of approximately 1,150 times.

pylar ends becoming somewhat narrow and pointed. The nuclei are found near the center or toward the micropylar end of the cells. As the egg enlarges it extends beyond the synergids. A large central vacuole develops (Fig. 2). The nucleus is located in the end of the cell away from the micropyle. The two polar nuclei, one from each end, move to the middle of the gametophyte and unite to form the large fusion nucleus (Figs. 3 and 4). Fusion occurs before fertilization.

In one instance fertilization in the potato ovule was observed 36 hours after pollination (Fig. 5). In this figure the large fusion nucleus appears to be about to unite with the male gamete. The egg is binucleate and one of these nuclei is presumably the male gamete just before fusion takes place. Cochran (2) reported that fertilization occurs 42 hours after pollination in *Capsicum fruitescens* L. at a temperature of 70° to 80° F. Smith and Cochran (9) found no instances of fertilization in *Lycopersicum esculentum* Mill. in less than 50 hours. Ferguson (4) reports that in Petunia the first divisions of the fusion nucleus occur before fertilization, the swollen tip of the pollen tube within the sac being sufficient stimulation to incite the development of the endosperm. However, Cooper (3) observed fertilization in the tomato and noted one case in which a male gamete nucleus was closely appressed to the nucleus of the egg, while the other male gamete was near the egg and at nearly the same level as the fusion nucleus. It would appear, therefore, that in the tomato the usual type of double fertilization occurs, a male gamete uniting with the primary endosperm nucleus before any endosperm divisions take place. The fertilization process in the potato appears to be similar to that of tomato. In any event it seems that under the environmental conditions existing at the time the experiment was conducted, the pollen tube reached the embryo sac in approximately 36 hours.

The first divisions in the endosperm take place well in advance of the division of the zygote. The dividing endosperm nucleus was observed in an ovule collected 46 hours after pollination. Another division figure (Fig. 6) was seen 58 hours after pollination, but other ovules in the same ovary had already undergone the initial steps ot endosperm formation, since more than one endosperm nucleus was present. No early, free-nucleate stage in the development of the endosperm was observed. The absence of a free-nucleate stage in the Solanaceae was first reported by Guignard (5).

Rees-Leonard (8) showed that disintegration may occur at any stage during the development of the potato ovule, although it is rarely observed in very young stages. Disintegration occurring immediately

after the meiotic divisions may be the result of irregularities in chromosome distribution. In the present study it was found that in some instances the fertilized egg appeared to be degenerating. Fertilization had evidently taken place, since the formation of endosperm tissue was well advanced. Disintegration is shown by shrinkage of cytoplasm and the appearance of dark-staining masses at the micropylar end of the embryo sac. Further studies are required to determine the nature of this degeneration of ovules and its importance as a factor in the poor seed-setting capacity of many commercial varieties.

The first division of the zygote or fertilized egg was not seen, but only one-celled zygotes were found in all collections made four days or less after pollination, whereas a number of two-celled embryos were found in later collections (Figs. 7, 8). It appears certain, therefore, that under the environmental conditions occurring in Maine during the period of this test, the first division of the zygote took place between four and five days after pollination of the flower. According to Cochran (2), in the pepper, the zygote starts division 24 to 36 hours after fertilization. Smith (9) found two-celled embryos in tomato ovules about 44 hours after fertilization.

The initial division of the zygote is transverse, and the two daughter cells again divide transversely, forming a four-celled linear embryo (Fig. 9). The linear arrangement of the cells of the four-celled embryo has been reported for other members of the Solanaceae by Souèges (11) and other workers. An eight-celled embryo is shown in Fig. 10.

A knowledge of the time which elapses between pollination and division of the fertilized egg is necessary in order to determine when various treatments, such as high and low temperatures, can be applied to best advantage in attempting to double the chromosome number. It is known from work with other crops that such treatments should be applied when the fertilized egg is dividing. It is hoped that polyploids may be obtained in the potato through chromosome doubling and that some of these will show desirable commercial qualities. In order to induce a doubling of the chromosome number by such methods as the heat treatment, it will be necessary under similar environmental conditions to treat the flower between four and five days after pollination.

Summary

A study was made in *Solanum tuberosum* L. of the time elapsing between pollination and fertilization, and between pollination and the first division of the fertilized egg. A knowledge of the time that elapses

between pollination and the first division of the fertilized egg is necessary in order to determine when various treatments, such as high and low temperatures, can be applied to best advantage in attempting to induce polyploidy.

In material collected at Presque Isle, Me., during the summer of 1938, fertilization of the potato ovule was observed 36 hours after pollination. The primary endosperm nucleus was undergoing its first division in an ovule collected 46 hours after pollination. The first division of the zygote or fertilized egg was not seen, but only one-celled zygotes were found in all collections made four days or less after pollination, while two-celled zygotes were found in later collections.

In some instances the fertilized egg appeared to be degenerating after fertilization had taken place, and this may sometimes be a factor in the poor seed-setting of commercial varieties.

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ERRATA

In the article by A. H. Eddins, in the December issue, page 309, line 3 of paragraph 2, *P. solanaceara* should read *P. solanacearum.*

In "Literature Cited," references 11 and 12, *"Saville"* should read "Savile;" and reference 13, *"Bacterium sepedznicum"* should read *"Bacterium sepedonicum."*

NOTES

The Federal Potato Breeders' Conference will be held in cooperation with the Department of Horticultural Research of Louisiana Agricultural Experiment Station at Baton Rouge, Louisiana from the 15th to the 18th of April, 1940. The conference will include inspection of the potato breeding work at Baton Rouge and also the testing stations at Lafayette and Houma, Louisiana. A half-day symposium on potato diseases will be held at the Alabama Gulf Coast Substation at Fairhope, Alabama. An opportunity will be given to inspect the testing work conducted at Fairhope by the State of Alabama.

Any one interested in Irish potato breeding and improvement work is cordially invited to attend these meetings.

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POTATO RESEARCH AT CORNELL UNIVERSITY[1]

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This morning I shall attempt to present results of potato research and in general the research program that we are now conducting at Cornell University. I shall confine these remarks entirely to my research work and that of graduate assistants[2] working with me in the Department of Vegetable Crops and in so doing trust that there shall be no accusations of self advertising. This affords me an opportunity to assemble and unify the work of a small group engaged in research on various phases of production and storage of potatoes and to present this to you. If investigators at other institutions, whether in this country or abroad, know of our problems, they may be able to offer us valuable assistance and again if they are more familiar with some of our work, there is the possibility that it may help them solve important questions in their locality.

POTATO ROTATION STUDIES

Mainly because of the increasing production of inferior potatoes, particularly insect damaged and diseased tubers which occurred under long rotation systems, the growers and research workers in our state initiated a program whereby it was hoped that some of these troubles could be alleviated without encountering too many other severe ones. Such a program has now been in progress for four years and involves

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[2]I wish to thank E. N. McCubbin, L. B. Nash, G. E. Davis and Fred McGoldrick, graduate assistants, who have kindly consented to the presentation of some of their material in this paper.

the cooperation of the Departments of Agronomy, Entomology, Plant Pathology and Vegetable Crops. Nine rotation systems in one location and 10 in each of two other locations are being compared. Potatoes grown each year on the same land with and without manure and rye cover crops are compared as to potato yields and quality with three 2-year and two 5-year rotations.

The results of the first four years were presented in a paper by Smith and McCubbin at the meetings yesterday so will not be dealt with in detail here. Highest yields in the southwestern New York and northern New York plots, both on quite acid soils, were obtained in rotations in which potatoes are grown every year and which receive applications of 12 tons of manure to the acre in addition to the commercial fertilizer. The highest yielding two-year rotation is one in which potatoes follow a one-year sod of clover and timothy grown for green manure. Lowest yields resulted in the rotation in which potatoes follow dry shell beans or soybeans for hay in a two year rotation. In the central-western New York plots on slightly acid to neutral soil higher in organic matter than the above two locations, no significant difference in yields existed among any of the rotations in 1937 or 1938. In 1939 the highest yielding rotations were of two years' duration, potatoes following corn for green manure and following dry shell beans. Manure applications in this area have not significantly increased the yields above similar rotations to which manure was not applied. Very marked differences in insect and disease damage to the tubers in the various rotations have occurred and the results are being reported at these meetings by those in charge of that phase of the work.

Fertilizer and Sidedressing Experiments

In attempting to explain the reasons for the tremendous increases in yields obtained from the manure applications particularly in southwestern New York plots we have been led into several other interesting problems. Among others the following possible causes of the increased yields have been considered; (1) temporary change in soil reaction, (2) nitrates and other forms of available nitrogen or potassium made available to the plant during a longer portion of the growing season than where commercial fertilizer only was applied, (3) the amount of nitrogen, phosphorus and potash in the commercial fertilizer is insufficient to support a maximum crop as it is when supplemented with that contained in a 12 ton per acre application of manure, (4) minor elements present in available form in insufficient quantities may be supplied in the manure, (5) the added organic matter may be improving

the physical condition of the soil to account for the increases (6) carbon dioxide given off by the manure may hasten or increase photosynthetic activity and (7) beneficial bacteria and fungi present in insufficient amounts may be added in the manure.

Several of these problems have received consideration. In 1938 an experiment was set up to determine whether some of the minor elements were available in sub-optimum amounts where manure was not applied. One thousand pounds per acre of 5-10-5 fertilizer were added to all plots. The following chemicals were all added to one set of plots and all but one to each of the next series of six treatments: manganese sulfate, copper sulfate, zinc sulfate, ferrous sulfate, magnesium sulfate and borax. The ninth treatment received 12 tons of manure to the acre in addition to the commercial fertilizer. The plots receiving manure yielded 65 bushels per acre more than plots of any other treatment, whereas the greatest difference between any two of the remaining treatments was only 23 bushels per acre with 24.4 bushels difference being necessary for significance. There was some indication that manganese may be present in insufficient amounts for maximum yields.

The soil reaction of the rotation plots at the beginning of these experiments ranged from pH 4.75 to 5.44. As shown by other experiments yields of potatoes may be markedly reduced by too low pH. Additions of manure may temporarily decrease the acidity sufficiently to result in an increased yield. However, in 1939 an application of 500 lbs. of hydrated lime to the acre at time of planting in addition to the commercial fertilizer did not result in any increased yield.

Another experiment was set up to test the possibility of the low yields occurring because of leaching of available forms of nitrogen or potassium, also to see if the additional nutrients in the manure were necessary to supplement the basic commercial fertilizer. The treatments included the basic application of 1,000 pounds 5-10-5 fertilizer to the acre all applied at planting time compared with one-half applied at planting time and one-half sidedressed in July; 2½-10-5 at planting time and the remaining nitrogen sidedressed in July; 5-10-2½ at planting time and the remaining potassium in July; all at planting time plus 2 per cent nitrogen in July and another 2 per cent in August; all at planting time plus the amount of nitrogen, phosphorus and potassium in a 12 ton per acre application of manure. Unfortunately owing to the extreme drought during most of the growing season in 1939 only small differences in yields were obtained. No treatment yielded significantly higher than the basic rate all applied at planting time. There were indications, however, that where less than 50 pounds of potash

per acre were applied at planting time the yields were lower than where 50 pounds or more were applied.

To determine the value of the organic matter in the manure a pot experiment with soil from this area has been set up with the following treatments: (1) 1,000 pounds 5-10-5 to the acre, no manure (2) 1,000 pounds 5-10-5 per acre plus the amount of nitrogen, phosphorus and potash in 12 tons of manure per acre applied as commercial fertilizer, (3) 1,000 pounds 5-10-5 plus manure at the rate of 12 tons per acre and (4) 1,000 pounds 5-10-5 per acre plus the ash from manure at the rate of 12 tons per acre.

Potash Experiments

Considerable interest has been shown recently throughout the state concerning the amount of potash necessary to produce maximum yields of potatoes. Three simple experiments, one in each of three of our widely separated potato areas were conducted during the past season. In two of the locations the fertilizer was applied at the basic rate of 1,000 pounds to the acre, in the third at the rate of 1,333 pounds. In each case a 5-10-5 fertilizer was compared with a 5-10-0, 5-10-10 and a 5-10-15. In northern New York under conditions of extreme drought particularly during the latter part of the growing season no significant differences in yield were obtained with the Green Mountain variety on gravelly loam soil. Undoubtedly this was a result of the drought. Usual rates of application in this area are 1,000 to 1,500 pounds per acre of 5-10-10 or 4-8-12. In another area on a sandy loam soil with the same variety but where the drought was much less severe there were significant increases in yields up to a 5-10-10 and then a slight decrease with a 5-10-15 analysis. With the Smooth Rural variety on a gravelly silt loam in southwestern New York where the drought was moderately severe, especially during mid-season, highest yields were obtained from the 5-10-15 analysis.

Seed Spacing and Rate of Fertilizer Application

Many of our growers who have poor soil or who do not make heavy applications of commercial fertilizer to their potatoes question the advisability of close planting of seed pieces in the row under those conditions. In order to obtain more complete data on this point an experiment was set up involving four planting distances: 10, 12, 14 and 16 inches between seed pieces, at each of the following fertilizer treatments: none, 500, 1,000 and 1,500 pounds 5-10-5 per acre. There were

no significant differences in yields between spacings at any of the rates of fertilizer application. It was apparent during the season that the main limiting factor for growth was moisture. Regardless of spacings there was an increase in yield from no fertilizer application up to the 1,500 pound per acre application.

Other fertilizer work has been conducted on Long Island cooperatively with the Bureau of Plant Industry, U.S.D.A. on comparisons of organic and inorganic sources of nitrogen, magnesium deficiencies, concentrated fertilizers, methods of application and others.

Soil Reaction and Green Manure Experiments

We have been interested for some time in the effects of soil reaction on growth, yield and amount of scabby tubers. Results of these experiments have been published. During the past two years green manure crops have been involved in these same soil reaction plots. Thirty plots range in reaction from pH 4.92 to 7.88. One-half of each of these plots has grown 8 crops of potatoes in the past 8 years without any cover crop or organic matter added, the other half of each plot produced six successive crops of potatoes, then in 1938 was devoted to growing silage corn in 14-inch rows which was plowed under as a green manure in September and seeded to rye which was plowed under the following spring. Potatoes were grown on all these plots in 1939. Potatoes are fertilized annually at the rate of 1,000 lbs. 5-10-5 per acre.

As in previous years' results total yields are lower in the plots of high pH than in the more acid soils and yields of scabby tubers are lower at low and high pH ranges than at intermediate ranges. At every range of reaction yields were much higher following the green manure crops than those following potatoes. Yields of non-scabby tubers are higher at each range of reaction following green manure than following potatoes whereas the per cent of scabby tubers at each reaction following green manure is lower than following potatoes. In 25 of the 30 comparisons the pH of the soil in which the green manure was incorporated was lower in July 1939 than in soil that had grown potatoes every year.

In another experiment which has been conducted during the last 3 years at Ithaca we are trying to find a good practical system of growing green manure crops one year followed by three successive years of potatoes. Some of these green manure crops are corn, rye, pearl millet, sudan grass, hemp, buckwheat, timothy and alsike clover, sweet clover, soy beans, blue lupine, Canada field peas and oats and sunflowers. These are compared with the continuous growing of potatoes with and

without manure or straw. All potatoes are fertilized annually at the rate of 1,000 pounds 5-10-5 to the acre.

In some cases where rye is seeded in the fall following potatoes and preceding a green manure crop such as millet which is seeded late next spring, the rye is allowed to mature and is combined in order to increase the amount of material plowed under and yet furnish a cash crop to the grower. No marked differences in yields have been obtained although potatoes have yielded highest as a rule following corn, sudan grass, sweet clover, sunflowers, soy beans and potatoes with 12 tons of manure to the acre. Lowest yields have occurred following buckwheat and potatoes with no manure or cover crop.

Seed Storage and Handling Methods

Numerous experiments have been conducted during the past several years, on methods of handling seed tubers involving such factors as storage, greening, sprout growth, chemical treatment, curing and waxing. The results, stated briefly, show that earlier come-up, shorter period from planting to blossoming and to maturity, and higher yields usually result from seed which has been stored at temperatures of 40° F. or above for a portion or all of the storage period. Recent work has shown that greened tubers result in no benefit as a result of having been exposed to light if sprouts are not removed from any of the tubers. Removing sprouts from any tuber just before planting regardless of previous treatment of the seed results in a greater number of stems per seed piece and usually a larger set of tubers. The main differences that have been noted in previous work comparing results from greened and ungreened seed have been caused by the effects of sprout removal from the ungreened seed rather than to the effects of light on the greened seed. Removal of sprouts, in addition to increasing the number of sprouts which replace those removed, results in a decrease in yield because of a pruning effect and delayed emergence and not because of removal of elaborated food or of growth substances.

Results of experiments through a period of years on the comparison of cured seed pieces with seed cut just before planting show that when soil moisture and temperature for a period of approximately two weeks after planting are conducive to curing of the seed piece that little or no benefits are derived from curing the seed piece previous to planting. However, when the temperature is too low or perhaps rarely too high and the soil moisture too low the healing process is prevented or progresses very slowly resulting in considerable seed-piece decay, poor stands and low yields. The latter conditions prevail so frequently in

most sections of New York State that curing seed before planting is highly recommended.

In 1939 experiments were conducted on muck and mineral soils comparing stands and yields resulting from seed pieces unwaxed and waxed with 50 per cent 333B* wax. It appeared possible that seed coated with a thin film of wax might be more resistant to seed piece decay and therefore take the place of the more tedious task of curing the cut seed. However, no differences in stand or yield were obtained this season. That soil conditions after planting were conducive to rapid curing of the seed was evidenced by the fact that no differences were obtained in the same experiment in stands or yields between cured and freshly cut seed. These experiments must necessarily be conducted under less favorable soil conditions before definite conclusions can be reached. In another experiment whole tubers which had been waxed with 40 per cent 333B wax in December stored at 40° F. and cut just before planting in June were compared with similar unwaxed tubers. No significant difference in loss of weight during storage or yield differences was obtained. There is some indication that sprout growth is slightly stimulated by waxing if it is done before the termination of the rest period. When the waxed tubers were cut in June it was noted that many of them were blackened in the center and were hollow hearted evidently as a result of the waxing treatment. None was noted in the untreated tubers. This indicates that 40 per cent 333B wax hinders the exchange of oxygen and perhaps other gases. Other tubers were cut in December, the surfaces allowed to dry several hours, then treated with 70 per cent 333B wax, stored at 70° F. for two weeks and then at 40° F. for six months. At the end of this period the waxed seed pieces were all moldy, shrivelled and dried whereas similar pieces cured for the 14 days at 70° but not waxed were in good planting condition at the end of the six months' storage.

Storage of Table Stock

Interest in better methods of potato storage has been revived recently by the Long Island potato growers as a result of low prices at harvest time. Most storage houses on the Island are of the above-ground type uninsulated and usually used for only a few months in the fall and early winter. Last year there was much concern about the condition of the potatoes in January and early February because of excessive sprout growth, dark skin color, black spots just under the

*Material furnished by Franklin Research Co., Philadelphia, Pa.

skin as well as other troubles. Storage experiments were started last fall in five houses varying in construction, ventilation, insulation or other features. Weighed samples of tubers were buried at various depths and in different locations with reference to ventilators, humidifiers, driveways, windows, etc. Near some of these samples atmometers also were covered to measure the evaporating power of the air in each location to compare with the weight losses from the tubers. Thermocouples also were placed inside the container in order that weekly temperature records could be obtained. Constant temperature and humidity records of the air in each house were obtained by a hygrothermograph. By this means we hoped to learn more regarding the efficiency and desirability of each type of storage, ventilation system, insulation and other handling methods for future recommendations.

To acquire some knowledge concerning the possible causes of the darkening of skin color of potatoes, lots of Green Mountain tubers grown on irrigated and non-irrigated soil were selected and stored at high and at low relative humidities at each of the following temperatures: 34°, 40° and 50° F. Results of these experiments have not yet been compiled.

Controlling Dormancy in the Potato

It would be desirable in some cases to obtain a practical method of inhibiting sprout growth of potatoes on a commercial scale when they are stored for a long period of time above the temperature at which they normally sprout.

Experiments are now being conducted in which storage in various percentages of carbon dioxide, nitrogen, ethylene and oxygen of waxed and unwaxed tubers as well as tubers untreated and treated with several growth substances are compared for their effects on sprout growth at several temperatures.

During the past year experiments on induced dormancy were conducted by treating whole and cut tubers with naphthaleneacetic acid, indoleacetic acid and water as a check. Tubers were immersed in 0.01 per cent solutions of growth substances for a period of 43 hours at 50° F. from the 6th to the 8th of April. They were potted on the 8th of April and placed in the 70°-80° greenhouse and transplanted to the field on the 7th of June. Indoleacetic acid treatment had practically no inhibiting effect on the growth of the plants in the greenhouse, whereas the naphthaleneacetic acid-treated tubers remained dormant about 6 weeks at 70° F. Subsequent yield data from the field show that indoleacetic acid-treated tubers had the largest number of

tubers per plant and the greatest yields, followed next by the naphthaleneacetic acid-treated tubers and lowest from those treated with tap water. In recent experiments volatilized methyl naphthaleneacetate and phenylacetic acid are being used.

In another series of experiments started November 1938 various combinations of treatments of whole and cut seed were made with indoleacetic acid, potassium naphthaleneacetate and water each treated and untreated with 70 per cent 333B wax and stored at 40° and 50° F.

Growth substances penetrated cut tubers more readily than whole tubers and therefore had a greater inhibiting effect in the former case. Treatment with wax did not appear to affect the results obtained from chemical treatments. Differences were obtained in sprout growth under the various conditions. But, when subsequently planted in the field, the yields obtained from the various treatments indicated that all tubers that had sprouts at planting time yielded equally well, regardless of treatments.

In another experiment sprouts from 2 to 10 inches in length were removed from tubers which had been stored at 70° F. in diffused light until the 6th of April. They were tied into bunches and immersed for 18 hours in water and 0.01 per cent solutions of naphthaleneacetic acid and indoleacetic acid and then placed in a sand cutting bench in the greenhouse. After 12 days in the cutting bench they were transplanted in 4-inch pots and placed in the 75° greenhouse. At this time sprouts which had been immersed in water had from none to 4 short roots per sprout, whereas those treated with naphthaleneacetic acid had 12 to 18 roots and the indoleacetic acid treated sprouts had 14 to 20 roots each. Naphthaleneacetic acid-treated sprouts had the most foliage growth, water-treated had the least. Water-treated sprouts had a greater enlargement resembling a tuber at the basal end than those treated with growth substances. All sprouts were transplanted to the field on the 5th of June and harvested on the 21st of October. Although fewer sprouts treated with water survived, they produced a greater number and weight of tubers per plant than those treated with growth substances.

Flowering Response to Environmental Changes and Chemical Treatment

We have been interested for some time in the possibilities of influencing flowering response in the potato by environmental conditions and more recently by application of chemicals. Under long day conditions the response to high and low nitrogen nutrition at 55° and 75°

is being studied. One-half the number of plants in each treatment is sprayed with naphthalene acetamide and the effects on number of flowers set and formation of the abscission zone noted. Special attention is being given to the latter process by microchemical tests and histological studies. The effects on flower production, fruit set and seed formation by treating tubers with trimethylamine are also being studied.

Some of the results of recent work with various growth substances on other plants led us to believe that they may have some influence on tuberization in the potato. Our study is applied to both wild and cultivated varieties of potatoes and includes the following factors: day length, air temperature, soil temperature, local effects of light and darkness, local effects of temperature and application of growth substances.

Studies on Hollow Heart

Our object in the hollow heart studies is mainly to determine the internal changes in the tuber resulting in or accompanying the hollow condition. Suggestions regarding the cause of this might include the possibility of a difference in pH sufficient to cause swelling of the colloids in certain regions or there may arise a difference in suction tension between the inner and outer regions of the tuber. In an attempt to induce pH changes tubers were treated by one of the following methods and sealed in airtight jars: indoleacetic acid, potassium napthaleneacetate, a paraffin base wax, water and no treatment. The pH changes resulting from these treatments were not large enough at the end of the second month to be important nor did any hollowness occur. Enough of a change was observed, however, to warrant repeating the experiment.

So much has been said about water relations in connection with the occurrence of hollow heart that it was decided to study the changes occurring in the inner and outer regions of the tuber as a result of raising and lowering the external water supply. Greenhouse work along this line indicates the value of doing further work of this nature in the field. No hollow heart was obtained in the field during the dry season of 1939 as a result of irregular fertilization.

Potato Cooking Quality Studies

Two papers were presented yesterday as progress reports of our research on factors influencing cooking quality of potatoes so that it

will be dealt with here very briefly. It was shown that alterations in the amount and intensity of sunlight during the period of tuber formation affects the specific gravity, dry weight, starch percentage, starch-protein ratio, soluble nitrogen, amino nitrogen, and texture and color of the cooked tuber. Although rather high rates of application of 5-10-5 fertilizer to potatoes has increased the yields it has decreased the specific gravity and slightly decreased mealiness. As potash applications varying from 1,000 to 1,333 pounds per acre of 5-10-0 are increased up to 5-10-15 the specific gravity and mealiness decrease slightly in the Smooth Rural and Green Mountain varieties. Only very slight differences in specific gravity and none in mealiness between irrigated and non-irrigated Green Mountain tubers could be detected.

The average specific gravities of Green Mountain tubers in a rotation experiment ranged from 1.093 to 1.110 and in Smooth Rural tubers from 1.091 to 1.096. Differences in mealiness in some cases varied from the specific gravity measurements. Tubers with higher specific gravity were produced in soils of high and of low pH than at intermediate reactions. Potatoes of a more mealy texture were produced in a soil of pH 7.88 than in soils of lower pH. More blackening of tubers also was noticed in tubers grown at a low pH (4.92 and 6.36) than at pH 7.88.

Other factors which are being studied as of possible importance from the standpoint of quality are sidedressing potatoes during the growing season with various fertilizers, controlled soil moisture, temperature and light during the growing season, stage of maturity, storage temperature and humidity, effect of certain anions and cations on texture (potassium vs. calcium, chloride vs. sulfate) effect of certain anions and cations predominating in the nutrient solution, relative effects of ions depending on their position in the lyotropic series (Ca, Mg. vs. K, Na and NH_4) and other factors. In each case specific gravity, chemical composition, texture and color of the cooked tuber are obtained.

COOKING QUALITY OF THE POTATO AS MEASURED BY SPECIFIC GRAVITY[1]

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In a potato breeding program which centers around the production of varieties for human consumption, a knowledge of the cooking or table quality is essential. There is no single universal standard of quality, since the most desirable one depends upon the individual taste of the consumer.

The cooking quality of a potato is made up of several characteristics, such as mealiness, flavor, color of flesh, and freedom from blackening on standing after cooking.

The results herein reported comprise a study of the relationship of tuber density to mealiness in potatoes. The problem originated from an attempt to find a rapid method of determining mealiness in potato varieties. Heretofore, cooking and judging the cooked product by a group of people has constituted an index of cooking quality. A mechanical measure for this character would greatly facilitate the work of the breeder in determining the degree of mealiness of potato varieties. It was thought that if dryness is desirable, this character should be correlated with specific gravity of the tubers. Such a system would require some simple and rapid method of determining the specific gravity if it is to be most useful. The use of salt solutions of certain densities for the elimination of lightweight stock of food products has suggested that a modification of this method might be applicable to this problem.

MATERIALS AND METHODS

The material used in these studies consisted of twelve varieties of potatoes grown at Aroostook Farm, Presque Isle, Maine. One hundred twenty tubers of each variety were used in 1937. A statistical analysis of the data derived from these 120-tuber lots compared with data obtained from 60 of the tubers included in each of these lots showed that the same information was obtained from the 60-tuber samples as from samples of 120 tubers. Therefore, only 60 tubers of each variety were used in the 1938 tests. The samples of each variety comprised

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[1]Paper presented at the 25th annual meeting of the Potato Association of America, Richmond, Va., Dec. 28-30, 1938.

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[4]Junior Home Economics Specialist, Bureau of Home Economics.

equal numbers of tubers of three sizes of the following weights: 5-, 6-, and 7-ounce.

The tubers were washed and numbered, then weighed in air and in water, and the specific gravity calculated. The tubers were then immersed in salt solutions of known density.[5] These solutions were prepared by dissolving table salt in water, bringing each solution up to the density required for its respective class by means of a hydrometer. The solutions, in 2½-gallon earthenware crocks, were arranged in order of their densities, forming a graduated series of 11 classes as shown in table 1. The lowest-numbered solution in which each tuber floated was recorded as the solution number for that tuber. To determine the degree of mealiness, the tubers were cooked by steaming and scored by two judges.

TABLE 1.—*Class limits of specific gravity determinations and density of the solutions used*

Class and Solution Numbers	Specific Gravity Class Limits	Density of Solutions[1]
1	1.0576 — 1.0625	1.0600
2	1.0626 — 1.0675	1.0650
3	1.0676 — 1.0725	1.0700
4	1.0726 — 1.0775	1.0750
5	1.0776 — 1.0825	1.0800
6	1.0826 — 1.0875	1.0850
7	1.0876 — 1.0925	1.0900
8	1.0926 — 1.0975	1.0950
9	1.0976 — 1.1025	1.1000
10	1.1026 — 1.1075	1.1050
11	1.1076 — 1.1125	1.1100

[1]These correspond to the mid-points of the specific gravity class limits.

[5]Since this manuscript was prepared for publication, a paper by Haddock and Blood entitled, "Variations in Cooking Quality of Potatoes as Influenced by Varieties" has appeared in the May, 1939, issue of this Journal which describes a method nearly identical with the one outlined in this paper.

Size of Tubers

It is desirable to know whether size of tuber is a factor to be given consideration in selecting a sample for testing for mealiness. To obtain information on this point, comparisons were made of the mealiness judgments of the tubers of the 3 respective sizes, 5-, 6-, and 7-ounce, furnished by the 20-tuber samples of each of these weights secured from the twelve varieties included in the tests for the two seasons.

Although there were small differences in the mealiness of the different sizes as shown by a comparison of the means, the differences were neither consistent nor statistically significant for any particular size for the two seasons. On the other hand, highly significant differences (value of F exceeded the 1 per cent point) existed between size of tuber in the specific gravity comparisons as determined by the solution method.

Effect of Season

The well-known response of the potato to environmental conditions suggests that the results of a single season may not be a reliable criterion for judging the behavior of a variety with respect to quality. That a marked difference may exist in mealiness in different seasons is shown by the results obtained for the two years, 1937 and 1938, the F value for seasons being higher than the 1 per cent level.

A further study of the data has been made by comparing the mealiness readings of 60 individual tubers of each variety for the two years. The frequency distributions and the weighted means are given in table 2.

If we take as the criterion of significance twice the standard error of a difference, which in these data is 0.30, it will be seen that only three varieties, Golden, 336-202 and 336-303, remained constant for mealiness during the two years.

The difference in seasonal response noted in these tests represents the influence of extreme environmental conditions, since 1937 was marked by an unusually long period of hot, dry weather, whereas in 1938 there was an excess of rain and cloudy weather during the greater part of the growing season.

Variation in Mealiness within the Variety

Contrary to a widespread belief that a high degree of uniformity should exist in vegetatively propagated material, several investigators have reported a wide range of variation in the composition of individual tubers within the variety.

Goldthwaite (2) concludes from the results of analyses of several

TABLE 2.—*Variation in mealiness within varieties, also variation due to season, based on judges' scores of individual cooked tubers*

Varieties and Years		Mealiness[1]					
		1	2	3	4	5	Means
Irish Cobbler	1937		2	2	12	44	4.63
	1938		1	7	51	1	3.87
46000	1937	1	1	4	13	41	4.53
	1938	2	2	12	39	5	3.72
336-123	1937	2	2	2	12	42	4.50
	1938	1	11	15	33		3.33
Green Mountain	1937	2	7	14	25	12	3.63
	1938			6	36	18	4.20
46125	1937	4	5	16	17	18	3.67
	1938			10	35	15	4.08
Earlaine	1937	5	5	17	28	5	3.38
	1938	16	35	9			1.88
Houma	1937	3	12	20	16	9	3.27
	1938	7	32	16	5		2.32
Sebago	1937	20	14	9	8		1.93
	1938	6	12	11	25	6	3.22
336-202	1937	24	23	10	2	1	1.88
	1938	17	30	10	3		1.98
Katahdin	1937	32	17	8	3		1.70
	1938	4	23	26	7		2.60
Golden	1937	46	13	1			1.25
	1938	40	16	4			1.40
336-302	1937	43	17				1.28
	1938	60					1.00

[1]Class 1 poorest, and Class 5 best, from the standpoint of mealiness.

hundred individual tubers that no two potatoes, whether of the same variety or from the same hill, have exactly the same composition.

The percentage of dry matter in tubers of the same variety was found by Johnson and Boyle (3) to vary from 21.07 to 27.18 and the percentage of starch from 14.65 to 20.76.

Dry matter determinations of individual tubers of Green Mountain and Parnassia, reported by Stevenson (4), showed a range of variation from 21.5 to 26.0 in the variety first named and 21.4 to 25.8 in the last named variety. The starch content in these varieties varied from 9.9 to 14.5 in Green Mountain and from 11.7 to 14.7 in Parnassia.

These variations in composition must necessarily be reflected in the culinary quality of the tuber, although there seems to be little agreement regarding the relationship of the various factors which constitute this characteristic.

A variation in table quality within the variety has been reported by Gilmore (1). In a study of the relation of depth of the tuber in the hill to its quality, he found that tubers located at a depth between 2 and 5 inches were superior to those situated less than 2 inches from the surface or at a depth greater than 4 inches.

In the experiments conducted by the authors, the results of which are summarized in table 2, the distribution of the mealiness ratings covered the entire range of classes in seven of the varieties in 1937 and in two in 1938. In only one instance was the distribution limited to a single class. The extent of the variation appears to differ with the variety and with the season.

Specific Gravity

The specific gravity of the samples tested ranged from 1.0576 to 1.1125. For convenience in tabulating and analyzing the data, this range was divided into eleven classes, designated by numbers 1 to 11, the mid-point of each class corresponding to the hydrometer reading of each of the eleven respective salt solutions as shown in table 1. Although the specific gravity readings of the individual tubers, as determined by both the methods of weighing and of immersion in the solutions, were not in all cases identical, they corresponded very closely, as will be seen from the correlation coefficient of .9567. This indicates that the immersion in salt solutions of known density is a reliable method of measuring specific gravity. Furthermore, it has the advantage of being more rapid than the usual one of weighing in air and in water.

Relation of Specific Gravity to Mealiness

The work of several investigators has shown that a high degree of relationship exists between specific gravity and starch content of the potato. Since starch is one of the important factors contributing to mealiness, it is reasonable to assume that specific gravity may be taken as a measure of this character.

The high coefficient of correlation between the specific gravity determined by the usual method of weighing in air and water and by immersing in salt solutions, as reported in a preceding paragraph, indicates that the latter method gives a sufficiently high degree of accuracy for mealiness determinations on the specific gravity basis.

The relationship of these characters is best shown by the regression coefficients, which are calculated for the two seasons separately and for the combined data for both seasons, with specific gravity taken as the independent variable and mealiness the dependent variable as shown in table 3.

These coefficients are highly significant as shown by the F values, found by comparing the variance between arrays due to linear regression with the deviations from regression. They are not exactly alike for the two seasons, but either one of them or the average between the two shows the same trend.

The distributions of the deviations from the regression line, based on the total data for the two seasons, are shown graphically in Fig. 1. A wide range of variability is evident, but a summation of the variants located at the upper end of the line shows that of the 422 tubers included in the four highest solution classes (Nos. 8 to 11, inclusive) 376, or 85 per cent, are found in the two highest mealiness classes.

In making a practical application of the regression line, if we move to the right from any given point, 2.12 solution classes there will be, on the average, an increase of approximately one class in mealiness.

This method of evaluating the mealiness of potato varieties has an important advantage over the cooking method in that it permits the tubers to be used for seed purposes after the solution readings have been taken, as the eyes of the tubers are not injured by immersion in the salt solutions.

TABLE 3.—*Regression coefficients and their differences, showing the relationship between specific gravity and mealiness for 1937, 1938, and the two years combined*

Coefficients			Difference between Coefficients		
Year	Coefficient	F Value for Significance[1]	Year	Difference	2 Times S. E. of Dif.
1937	.5432	672.24	1937 and 1938	.1181	.0376
1938	.4251	2882.34	1937 and (1937 + 1938)	.0717	.0208
1937 + 1938	.4715	1850.00	(1937 + 1938) and 1938	.0464	.0327

[1]The 1 per cent point of these values is approximately 6.69 for 1937 and 6.66 for 1938 and for the combined data.

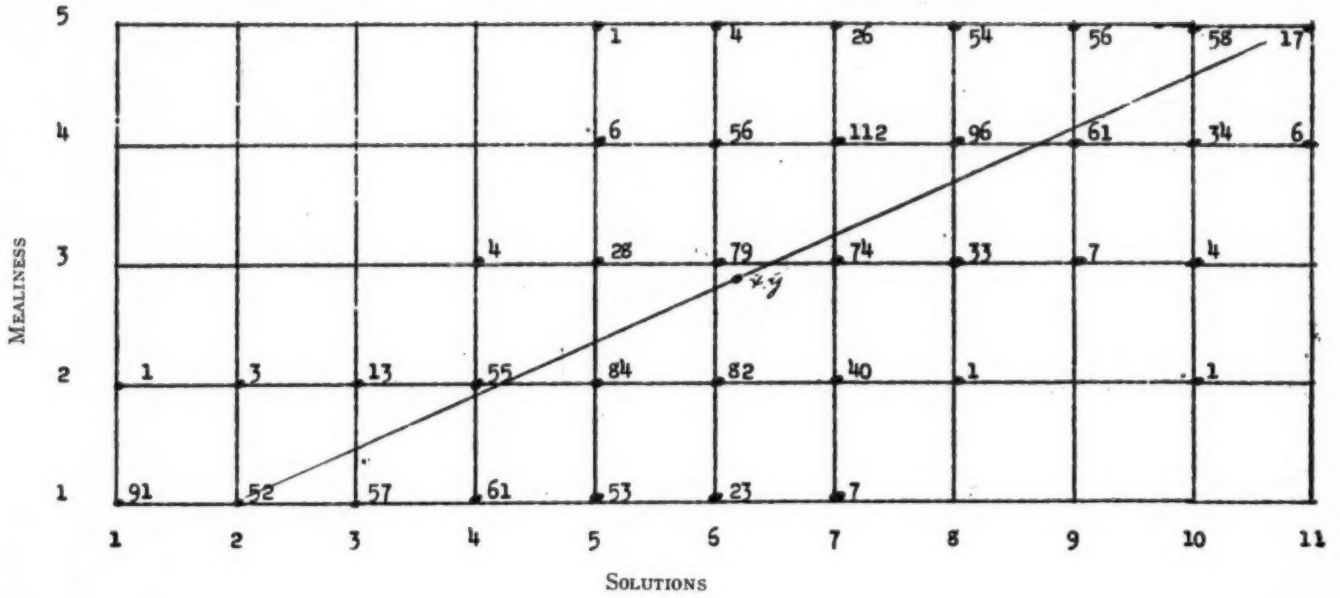

FIGURE 1.—*Regression line for mealiness on salt solution readings and scatter diagram showing the relation between these variables. Based on data for* 1937 *and* 1938

Conclusions

The highly significant interaction between seasons and mealiness indicates that a single season's test is not a sufficiently adequate basis for rating the mealiness of a variety.

The two methods of measuring specific gravity employed in these tests gave approximately the same results. Since the salt solution method is more rapid, it is preferable to the more laborious method of weighing in air and water.

The use of salt solutions of known densities was found to be a practical method for making a preliminary selection for mealiness. The study of large populations can be greatly facilitated by employing this method, since much less time is required than by the usual cooking method. Furthermore, the material tested may be used later for planting.

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A PROMISING METHOD FOR ERADICATING BACTERIAL WILT AND RING ROT FROM THE POTATO

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The history and progress of bacterial wilt and ring rot of the potato on this continent have been adequately described elsewhere[2] and need not be repeated here. Suffice it to say that the disease is so widespread as to cause serious economic loss to growers and to elicit the interest of investigators in all of the potato growing sections of the country.

The senior author, after several years of observation and attempted eradication of the disease by the application of sanitary measures on the part of growers, concluded that if the disease were to be eliminated, radical measures were needed to develop seed stocks free from infec-

[1]Departments of Horticulture, and Pathology and Bacteriology, respectively.
[2]See literature cited.

tion. With this in mind the following procedures were planned and the junior author was invited to execute the technical details of the problem.

A bacterium similar to that described by Spieckermann and Kotthoff (1914) and Stapp (1930) has been deemed to be the etiological agent by Savile and Racicot (1937), Burkholder (1938) and others, as well as by ourselves. This organism is known as *Phytomonas sepedonica* and is a small, coccoid, Gram-positive, non-spore forming bacillus. Its morphology and staining characteristics, fortunately, permit an approximate microscopic identification in the presence of other bacteria that may invade the tuber or stem of the potato.

Methods and Results

I. Nineteen lots of seed potatoes were secured from sources believed to be nearly free from infection. These were sent to the Mountain Substation of the Colorado Agricultural Experiment Station at Minturn, Colorado. The following varieties, standard for Colorado, were represented: Bliss Triumph, Chippewa, Irish Cobbler, Katahdin, Red McClure, Rural New Yorker, Russet Burbank, Russet Rural, and White Rose.

Each lot was treated in the following manner. The tubers were first washed by dipping in a solution of Semesan Bel. Each tuber was then cut through near the stem end and the vascular ring was examined for discoloration. All tubers showing vascular discoloration were discarded.

From each tuber showing no discoloration a segment was cut to contain a portion of the vascular ring and this was pressed against a microscope slide for the purpose of leaving an imprint of the vascular ring. After smearing, each tuber was dipped into a solution of Semesan Bel to disinfect the cut surface. The smears were arranged serially, as were the slides, six smears being placed on each slide, and the tubers were correspondingly arranged on platforms in the storage cellar to be held pending microscopic examination of the smears.

The smears were fixed by heating in the flame of a gasoline torch and were stained by the Gram method, using the modification recommended by Racicot, Savile, and Connors (1938). A binocular microscope, employing the oil-immersion objective, 7.5X oculars, and a mechanical stage, was used to examine the smears for the presence of Gram-positive bacteria corresponding morphologically to *Phytomonas sepedonica*. The smears were recorded as being "—", "±", "+", "++", "+++", or "++++", depending upon the greatest number of typical bacteria found in any microscopic field.

All tubers from which smears exhibited any typical bacteria were discarded. The tubers from which smears appeared to be negative were partially cut through to form four seed pieces. The knife was dipped into a solution of Semesan Bel after each tuber was cut, to prevent the spread of infection. An assisted-feed planter was used and the tubers were planted in tuber units in a field that had supported alfalfa for the past eleven years and that was separated from other potato fields by a distance of one mile. The field was irrigated with water from a mountain stream that had no contact with other fields of potatoes.

The examination of smears was begun on the 1st of June and the last lot of tubers was planted on the 28th of June, 1939. The results of this procedure may be seen in table 1.

TABLE 1

Variety	No. of Tubers Examined	No. of Tubers Discarded	Percentage of Tubers Discarded
BLISS TRIUMPH			
Strain B	858	62	7
Strain G	510	92	18
Strain M	210	10	5
Strain R	431	247	52
Strain S	65	17	26
CHIPPEWA	120	25	21
IRISH COBBLER			
Strain J	426	157	37
Strain M	366	91	25
KATAHDIN			
Strain G	300	127	42
Strain R	240	19	8
RED McCLURE			
Strain SS	147	3	2
Strain S38	111	8	7
Strain S39	107	12	11
Strain S47	104	2	2
Strain S84	123	2	2
RURAL NEW YORKER	168	39	23
RUSSET BURBANK	222	13	6
RUSSET RURAL	204	44	22
WHITE ROSE	168	55	33
All varieties	4880	1025	21

Throughout the summer the plot was inspected at frequent intervals and tuber units were removed whenever any plant therein gave evidence of virus, fungous, or bacterial infection.

On the 29th and 30th of September and the 1st of October, the plot was harvested. Because of a limitation in time only fourteen of the lots were selected for further study. The tubers were dug by hand and the increase from each unit was sacked separately and tagged. At the time of digging, a stem from each hill was cut at the base and smeared on a microscope slide in order to leave an impression of the cut surface. Eight smears, representing two units, were placed on each slide which was labelled to correspond to the sacks in which the tubers from those units were placed. The sacked tubers were stored in the cellar. The tubers from a unit from which any smear exhibited typical bacteria were discarded. The remaining tubers will be offered to selected foundation seed growers for further increase under the supervision of the seed-certification staff. The results of the microscopic examination of stem smears may be seen in table 2.

II. Because of geographic separation, lack of time, and personnel, the method described above was modified in the case of a grower of foundation stock who operates near Monte Vista, Colorado, in the San Luis Valley. By methods of selection this grower has developed four especially desirable strains of the Red McClure variety. In an attempt to free these strains from possible infection one of us (C.H.M.) visited the San Luis Valley while the work was being conducted at the Mountain Substation.

One hundred and fifty tubers of each selected line were cut and smears made as described above. The tubers were planted at once in tuber units. These were arranged serially to correspond with the smears. At the time of planting each seed piece was numbered with an indelible pencil. The numbers were clearly distinguishable on those seed pieces that were later removed from the soil. The slides were then sent to the Mountain Substation where they were stained and examined. The examination was completed two weeks after planting and the seed pieces in which bacterial infection was suspected were removed from the soil when the report of microscopic examination was submitted to the grower. Therefore, delay in planting was avoided.

Of the 600 tubers examined 53, or 9 per cent were discarded. Of the apparently infected smears 28 were designated "±" and were probably soil contaminated whereas 28 were reported as being "+".

During the growing season the field was inspected twice by us and frequently by the grower. Two suspected units were removed from

TABLE 2

Variety	Smears Examined	Units Represented	"Positive" Smears	Per Cent of Smears "Positive"	Units Discarded	Per Cent Units Discarded	Units Discarded from Probable Soil Contamination of Smear
BLISS TRIUMPH							
Strain M	80	20	0	0	0	0	0
CHIPPEWA	40	10	0	0	0	0	0
IRISH COBBLER							
Strain J	40	10	1	2	1	10	1
Strain M	160	40	4	2	3	7	1
KATAHDIN							
Strain R	320	80	2	1	2	3	2
RED McCLURE							
Strain SS	160	40	5	3	4	10	3
Strain S38	160	40	31	19	11	27	3
Strain S39	164	41	15	9	8	20	2
Strain S47	160	40	18	11	11	28	3
Strain S84	160	40	2	1	2	5	1
RURAL NEW YORKER	80	20	1	1	1	5	1
RUSSET BURBANK	40	10	1	2	1	10	1
RUSSET RURAL	40	10	0	0	0	0	0
WHITE ROSE	80	20	1	1	1	5	1
ALL VARIETIES	1684	421	81	5	45	11	19

the 547 units that had been allowed to grow following the report of tuber smear examination.

III. In an effort to secure a bacterial-wilt-free source of the Peachblow variety one of us (D.P.G.) visited the mountain ranch of a grower at Divide, Colorado, on the 22d of September, 1939, about three weeks before the time of harvest. Stems from each of 714 hills were cut at the base and smeared on microscope slides. The hills were staked and numbered to correspond with the serial arrangement of the smears. An examination of the smears was completed before harvesting. All of the smears appeared to be negative, and upon this evidence the crop harvested was believed to be free from bacterial wilt.

Discussion

During the examination of smears at the Mountain Substation several lots appeared in which diagnosis was made difficult by the presence of soil particles and numerous bacteria of diverse morphology of which the majority were gram-positive. These evidently came from some external source. Further investigation proved that the tubers from which the smears were made had not been washed. Our attention was thus drawn to the importance of cleaning the tuber surface prior to routine examination. Subsequently smears were made from the skins of unwashed tubers. These revealed that the outer surface of the tuber was densely populated with a variety of bacteria. The problem of external contamination of the smears might be obviated by the technique applied by some that consists of tearing away a portion of the cut segment to afford a clean surface for smearing. This method, however, proved too slow and laborious for our use.

The most difficult problem that confronted us in the examination of smears was that of determining what number of microorganisms in any microscopic field should be interpreted as constituting an index to infection. It was arbitrarily determined that a smear exhibiting any bacteria of proper morphology should be designated as being at least "±". Our experience, however, has led us to the conclusion that the majority of tubers discarded were not actually infected and that where such infection exists a considerable number of bacteria will appear in some microscopic field. Although in a few cases, probably caused by careless smearing, the bacteria were found widely spread, the majority appeared in small areas apparently where vascular tissue had been pressed against the slide.

When tuber smears are made so that six smears may be placed on one microscope slide, only a small portion of the vascular ring may be

impressed upon the slide. We believe that in a tuber so slightly infected as to exhibit no vascular discoloration the entire vascular system may not be invaded by the bacteria. For this reason the smear may not reveal the microorganisms when they may be present in some portion of the vascular ring. On the other hand, when stem smears are made, an impression of the entire vascular ring is available for examination and the opportunity for error is less. With these observations in mind we are inclined to favor the examination of stem smears as being a more reliable index to infection. After several months of experience in the examination of such smears we believe that we are able to recognize infection when the 10X objective is substituted for the oil-immersion objective of the microscope. Therefore a more rapid survey of the smear is permitted. Although individual bacteria are not discernible, the purple color and the finely and uniformly granular appearance of the field may be considered diagnostic. Microscopic particles that are not bacteria are usually found to be coarse, irregularly arranged, and opaque when viewed with the low-power objective. To date, each suspected microscopic field also has been examined with the oil-immersion objective for the purpose of confirmation.

Although some investigators have expressed the opinion that all lots of seed potatoes showing bacterial wilt should be discarded, we believe that it is possible to eradicate the infection by the methods described above. This is especially desirable when a lot represents a variety or strain that may not be easily replaced in a particular growing section.

The microscopic examination of stem smears has been of great diagnostic value when, in certain varieties and under certain field conditions, difficulty is experienced in distinguishing the vine symptoms of bacterial wilt in the field from those of black leg and the wilt caused by *Fusarium oxysporum*. Especially is this true when two or more of these infections are present in the same field and when it is necessary, for purposes of certification, to enforce a zero tolerance for bacterial wilt while permitting certain percentages of other infections to obtain.

Summary and Conclusions

Microscopic examination of tuber and stem smears has been applied to the eradication of bacterial wilt and ring rot from seed stocks of the potato. Of the 5480 tubers examined, comprising 24 lots and 9 varieties, 20 per cent were discarded, although only a small proportion of these are believed to have been actually infected. The percentage

discarded from the individual lots varied from 2 to 52 per cent. Of the 1684 stem smears, representing 421 tuber units and 14 lots, 5 per cent exhibited microorganisms, resulting in the discarding of 11 per cent of the units. An additional lot of 714 stem smears from one field of potatoes appeared to be free from infection.

When only one type of smear may be examined, that made from the base of the stem is believed to prove the more reliable index to infection.

We have concluded that these methods seem adaptable to the eradication of bacterial wilt and ring rot infection from seed stocks of the potato.

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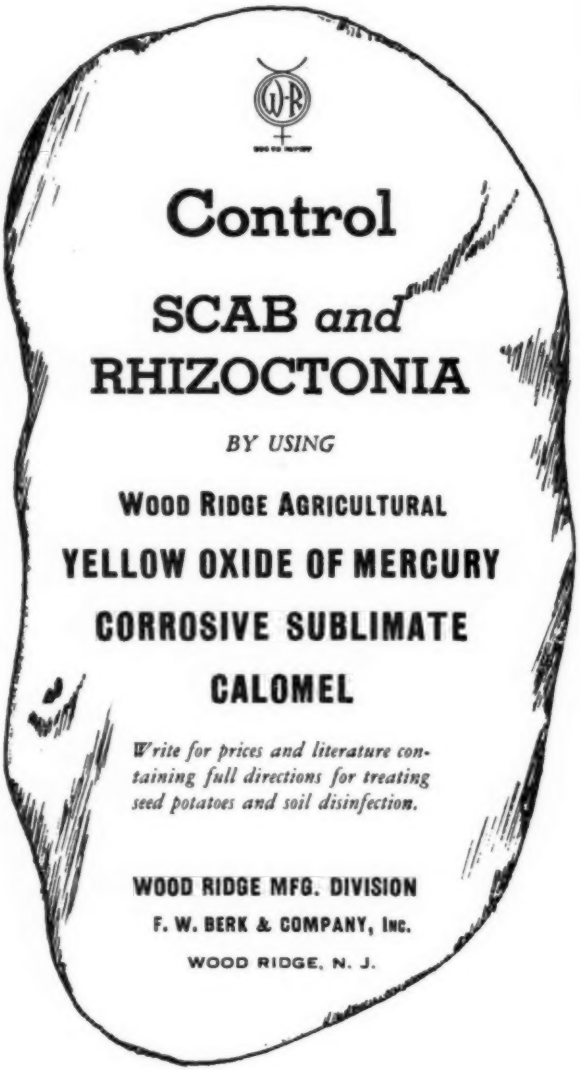

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CERTIFICATION METHODS AND SUGGESTED CHANGES

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The article in the January, 1940, issue of the American Potato Journal by L. M. Ware of the Alabama Experiment Station, Auburn, Alabama, entitled "Certain Aspects of the Alabama Field Tests of Seed Potatoes as a Requisite for Certification," opens up a field of discussion which is of greatest importance to potato growers in every part of the United States.

Any one who has made a close study of seed potatoes, based on productivity in the areas where potatoes are grown for commercial production will highly commend the conclusions so ably and clearly stated by Mr. Ware.

The purpose of this paper is to suggest changes in certification specifications and methods of inspecting that may lead to a greater uniformity in certified seed than exists at present.

Certification at the present time deals very largely with the following factors: (1) bacterial diseases; (2) fungous diseases; (3) virus diseases; and (4) grade—stressing (a) appearance; (b) size; (c) shape; (d) maturity, and (e) fungous and bacterial infections.

In the writer's opinion these four general headings should be supplemented by two additional factors, namely (5) hereditary characteristics and (6) physiological factors.

The justification for including hereditary characteristics rests in the theory that commercial seed lots of all varieties deviate more or less from the normal because of mutations, and by mixtures with similar but differently behaving strains within the same variety and perhaps from causes that are not now recognized.

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Without attempting proof of the causes of non-homogeneity in commercial lots, the fact is quite apparent that there is a wide difference in behavior between individuals in all commercial seed lots. The more nearly a seed lot is uniform in hereditary characteristics, the greater will be its uniformity when grown for commercial purposes. Good, poor and indifferent homogeneous lots can be accurately proven by growth tests in the commercial areas. A proven, good homogeneous lot when used for foundation stock will produce certified seed that is superior to certified seed that has been grown from random selected foundation stock.

The inclusion of physiological factors in "seed certification specifications," such as the effects of temperature, moisture, character of soil, nutrients in the root zone, rate of respiration and absorption of oxygen by the tuber, may better be left to the future until more accurate knowledge has been obtained by careful scientific physiological investigation.

That these factors influence vigor and uniformity of growth is quite apparent to the careful observer and they undoubtedly form part of the difference in seed lots that are now certified. These factors are independent of virus, bacterial, fungous, or hereditary characteristics.

In the meantime, if the difference between certified lots is to be abated, certification should only be granted to those areas and specific fields where a continuous test over several years has proven that the physiological factors in the individual field are such that vigor and uniformity of growth are obtained. To certify potatoes from fields and areas that have not been proven is to place a premium on inefficiency.

Bacterial and Fungous Diseases

No one can have the slightest objection to a compulsory absolute freedom in seed lots of the pathogenic bacteria such as bacterial ring rot, or southern brown rot, or any other that are now in existence or may appear. The fungi, based on past knowledge, are probably well disposed of under present certification standards although the organisms and their effects on seed should be studied more thoroughly.

Virus Diseases

In general, most certified seed specifications relative to virus are adequate. The trouble with respect to virus is that in practice and in field work the viruses are not properly recognized. It is the non-recognition of both degenerate and latent viruses that part of the difference

in various certified seed lots described by Mr. Ware is to be found. For instance, in the White Rose variety there are several symptoms in the vine that show a deviation from the normal healthy plant. In fertilized fields, particularly with adequate moisture, these symptoms very seldom appear. In greenhouse indexing the symptoms are only apparent on cloudy days, disappearing with sunshine and reappearing with cloudy weather. In non-fertilized fields the symptoms are only apparent for a very short space of time early in the life of the plant.

Constant observation covering several years has proven that if vines showing these symptoms are not removed, the number of vines so affected increases yearly and to the extent that finally every vine in the field deviates from the normal. When this happens the abnormal becomes normal, the field is certified and the yields from this seed drop from 50 to 200 bushels per acre compared with certified seed that is normal. There are many areas where certified White Rose seed is grown for sale to commercial areas where there is not to be found a field that contains more than one or two per cent of normal, healthy White Rose plants.

The cure for this condition is accomplished by several years of intensive roguing of entire units from fields planted on a tuber unit basis and which are rogued at a time when the symptoms can be seen. The raising of a small tuber unit seed plot, followed by mass planting the next year to produce foundation stock for production of commercial seed the following year, is not effective.

Examination of fields that are not on a tuber unitted basis or that are examined whenever a crowded calendar enables an inspection, will not disclose these vines. Likewise vines in the testing plots located in commercial areas will not disclose these viruses except under very favorable conditions and only for a short period of time. The infection is only reflected in the drop in yields which becomes severe when vines that deviate from the normal have a secondary virus infection imposed on them. The present method of inspecting fields for certification in most states does not recognize these facts and inspection services to be competent must embrace methods of time of inspection so that these symptoms are seen.

Mild infections of common degenerative viruses cannot always be seen in certain fields planted on the mass plan. To overcome this condition, seed entered for certification should be planted on the tuber unit plan and if not so planted, should not receive a Grade A certificate.

Grade

At the present time certification specifications place a great deal of importance on grade requirements and many buyers depend very largely in their judgment of seed on grade specifications. Most certified seed specifications demand a U. S. No. 1 grade. A U. S. No. 1 grade requires a good appearance, uniformity of size and shape, and an attractive condition of skin. There is no basis in fact for the assumption that any of these several factors are of real importance in the evaluation of good seed. The imposing of these grade restrictions makes the cost of seed so high that the buyer is either unwilling or not able to pay the price. Furthermore, in order to grow a payable crop of U. S. No. 1 grade potatoes, it is necessary to grow them in fertilized fields or one that has adequate food value and optimum moisture, which conditions unfortunately, tend to mask virus symptoms. If a seed buyer wants disease-free seed at a fair price, he must give ground on grade requirements implicit in the U. S. No. 1 grade.

Certification specifications should be changed so as to eliminate any requirements regarding appearance, size, shape, and condition of skin, and until this is done and so long as a premium is placed on these characteristics, certified seed is going to suffer because disease cannot be removed from fields that produce a payable crop of U. S. No. 1 grade.

Hereditary Characteristics

The mixtures now prevailing in commercial seeds of all varieties are evidence of factors that have received little attention in the past. Hardly any seed lot of any variety can be examined that does not show a variation in yields, shape, color, and tendency to produce undesirable potatoes that can be explained by disease or grade—the two factors that now determine certification.

An examination of potatoes from various hills in a field discloses many variations. About one Green Mountain out of five grown in Maine runs true to shape. Deviation in color within individual plants in the red varieties is evidence of a departure from normal. In the White Rose variety there is a marked variation in individuals in yield, shape, and tendency to second growth. There are many other examples of the mixtures that have taken place.

The thought is not that every vine can be made to produce equal to every other vine but is, that through a selection of lots that are homogeneous in that they have been produced by multiplication over several years from the same potato, that they will be uniform enough so that a selection of desirable homogeneous lots can be made and that this

selection will be more accurate than a selection resulting from a bin selection of individual potatoes or from staked vines. These methods do not provide any means of proving the value of seed when planted for commercial reproduction. The selection of homogeneous lots or families, based on performance in areas where the seed is planted commercially is much more accurate.

It also follows that a lot of certified seed that is grown from a homogeneous family that has been tested and proven in the area where it is to be grown commercially and found there to be desirable, is better than a certified seed lot grown from a mixture that is untried and unproven and which contains individuals that are good, bad and indifferent.

The unscrambling of commercial seed lots is practically possible and the creation of homogeneous families or strains should be made a requirement of certification. Great effort and expense is involved in the process but there is no easy road to good seed potatoes.

Until these things are done, the buyer of seed in commercial areas will continue to find differences in seed lots both of which are certified and very often equally priced.

Physiological Factors

As suggested in the introduction, most of the physiological factors are now unknown and their application in certification must await further study. In the meantime the result of testing of seed for vigor and uniformity in areas of commercial production should be referred to the Certification Department of the states where seed is grown. All areas and fields entered for certification in these states must, after a given time, be proven by test that there is no inhibiting factor which destroys the vigor and uniformity of seed produced.

Summary

For certification to progress beyond the present unsatisfactory state as evidenced by the great difference between certified seed lots when grown in test plots in commercial areas, several changes in certification are suggested—

a. A more thorough knowledge of latent viruses and their effect in relation to secondary infections.
b. Inspection of certified fields when the symptoms of virus can be seen.
c. Granting of "Grade A" certification only to fields planted on the Tuber Unit Plan, reserving "Grade B" for mass planted fields planted from Tuber Unitted Seed the previous year.

d. Certifying as "Grade A" only fields that are grown from homogeneous foundation stock that has been proven to be desirable in commercial areas.

e. Certifying only areas and fields that have been proven by tests in commercial areas that there is no impairment of vigor and uniformity of growth resulting from physiological factors which are at the present time not clearly recognized.

f. Remove from certification specifications any restriction imposed by grade rules limiting shape, size, appearance and condition of skin.

g. Certifying no lots where pathogenic bacteria are found.

POTATO CULTURE AND STORAGE INVESTIGATIONS IN 1938 AND 1939[1]

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In reviewing the reports of investigations on potato culture and storage published during the past year, it is evident that there were fewer than usual on these phases of the industry. A majority of these reports deal with storage which may indicate that there is relatively greater demand for information on this subject. Some of the foreign reports are not readily available and these are referred to only in the list of citations. Furthermore, those papers which were read at the last annual meeting of the Potato Association of America and later published in its Journal are not reviewed here.

CULTURE

Time of planting as related to yield and quality of potatoes is known to be especially important in regions of a relatively short growing season. This is particularly true in Finland as shown by Vesikivi (21) in an experiment made with the variety Up-to-date in 1936 and 1937. Planting at three successive dates through late May and early June, he obtained the largest yields and the highest starch content of tubers with the earliest plantings. Cutting off the tops in late September to prevent the spread of late blight on the tubers was tried on both peat and upland soils. This practice did not appear to appreciably affect either yield or quality.

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[1]Published as Paper No. 214 of the Department of Vegetable Crops at Cornell University.

The relation of size of seed piece to optimum spacing at planting time is a matter which has been studied and reported by numerous investigators for many years. During the past year, Tinley and Bryant (19) of the South-Eastern Agricultural College at Wye, England published results of a 6-year experiment with varieties Great Scot and King Edward. Seed graded uniformly to four sizes was spaced in Latin-square plots at distances of 12, 15, 18 and 21 inches. Averaging yields for all spacings, large sets gave the highest total yield, yield of ware and seed. The 12-inch spacing gave larger total yields, yields of ware and of seed size than any other spacing, all four sizes of seed being considered. In general, the results indicated that on the basis of net yields, the larger seed sizes should be spaced wider than the smaller size. The authors concluded that it would be profitable for the grower to grade his seed to size and plant each size at its optimum spacing.

In the south of England where potatoes are commonly planted in rows 27 inches apart and are mainly of the Scotch varieties, King Edward VII and Majestic, there is much interest in the relation of size of sets to yield. Thompson (16), using the Majestic variety, recently reported results from six seed sizes the largest being 2¼ to 2½ inches and the smallest 1 to 1¼ inches diameter. In these tests all sizes were spaced 16 inches in the row. In each instance, the largest sets gave highest yield of both ware and seed size in the crop although the smallest sets gave the lowest yield. These results with Majestic differed from those previously reported for King Edward VII variety wherein best yields were obtained with medium-sized seed (1½ to 1¾ inches).

Results of a 7-year experiment to test the effects of time of irrigation on stolon and tuber development in Rural and Triumph varieties were reported by Edmundson (6) at Greeley, Colorado. Both varieties were planted about the 12th of June, the first water being applied from 2 to 3 weeks later for early irrigation, and 5 to 7 weeks later for the late irrigation practice. The early applications lowered the soil temperature more than those applied late and resulted in greater stolon and tuber development for both varieties.

Further information on the comparative productiveness of peat grown and upland grown seed potatoes was reported by Albert, Larson and Walker (1) of the Wisconsin Station in 1939. Trials using Cobbler, Katahdin, Russet Burbank, and Rural New Yorker varieties were made in 1935, 1936 and 1937. Except in 1935, the seed was all stored in the same cellar and planted back the following year on both peat and sandy soil for yield comparison. In 40 of the 47 direct comparisons,

the peat grown seed outyielded that from sandy soil. Although there were certain instances of a reversal in results, and sometimes the differences in favor of peat grown seed were small, the authors agree that peat grown seed may be expected to give superior yield. It was common observation that the peat grown seed gave more vigorous plants immediately following emergence.

A brief but rather comprehensive record of recommended potato growing practices in Egypt was made by Harari (11) and published in the May, 1939 issue of the Bulletin of the Union of Agriculturists of that country. Irrigation is necessary and potatoes are grown mostly as a winter crop in rotation with corn and cotton. Seed is imported from Ireland, England and Italy and is the principal item in cost of production. An itemized budget of the factors concerned in production indicates a total of approximately $115.00 to the acre.

Storage

Thornton (17) shows that the effectiveness of carbon dioxide in breaking the dormancy of potato tubers is not caused by temporary anaerobiosis as reported by certain other investigators. On the contrary, carbon dioxide was most effective when used in the presence of 20 per cent or more of oxygen. He concludes that a 5 to 7 day treatment with concentrations of 10 to 60 per cent carbon dioxide and 20 to 80 per cent of oxygen are most effective in breaking the dormancy of freshly harvested tubers.

In a later paper, Thornton (18) gives the results of an experiment which he interprets to mean that a relatively low concentration of oxygen is more favorable for the sprouting of dormant potato tubers than is a high concentration. These results, apparently contrary to those of most other investigators, he explains on the basis of the permeability of potato tissue to oxygen at various stages of maturity and under different conditions of storage humidity and wound periderm. For example, newly harvested tubers usually do not sprout because the bud tissue then most permeable, absorbs enough oxygen to inhibit growth. Similarly, he explains that cut seed often sprouts more quickly than whole tubers because the resulting wound periderm reduces the amount of oxygen absorbed. Thornton's results indicate that an atmosphere of 2 to 10 per cent of oxygen is much more effective in breaking dormancy than the normal 20 per cent of the air.

Further results of experiments on breaking the rest period of seed potatoes were recently reported by Pal and Nath (14) in India. Although no yield differences were given, germination counts indicated

that the ethylene chlorhydrin vapor and dip methods used on cut seed were more effective than was the dip method on whole seed. Peeling and subsequent storage in moist sawdust for one week gave best results but is not to be recommended commercially because of the labor of peeling.

One of the most recent studies of the practical value of chemical treatment to break the rest period of potato tubers has been reported by Woodbury (22) of Idaho. Treating dormant Russet Burbank tubers for one hour in a 4 per cent solution of potassium thiocyanate and in 4 per cent thiourea gave a marked increase in earliness of sprouting, in number of sprouts per seed piece and number of tubers per plant. Thiourea was more effective than potassium thiocyanate in inducing multiple sprouting. As the result of treating cut seed for the greenhouse trials and uncut seed for the field tests, the author believes that results are more marked from the treatment of cut seed.

In the southern states where both a spring and a fall crop of potatoes may be grown, the grower has a choice of three types of seed. Kimbrough (12) in a 3-year experiment at the Louisiana Experiment Station compared the yields resulting from Louisiana spring grown, Louisiana fall grown and northern grown seed of Katahdin, Chippewa, Houma and Triumph varieties. The length of dormant period averages about 5 months for northern seed, 9 months for Louisiana spring grown and 3 months for fall grown and has a marked influence on the resulting yield. In every case, the northern seed outyielded both Louisiana spring grown and fall grown, the difference being especially great in the case of the spring grown lots. Kimbrough concluded that for best results the dormant period should be long enough for the seed pieces to sprout rapidly when planted but not so long as to promote multiple sprouting and stunted early maturing plants.

Henry (10) has investigated the possibilities of growing a second crop of potatoes following the main crop in Uruguay by testing the importance of length of dormancy of seed and methods of storing the seed crop through the summer months. He reports that a satisfactory method of summer storage is by the use of an aerial silo covered with straw, the seed tubers to be later aerated in boxes for a short period prior to planting in August.

Singh and Mathur (15) stored potato tubers in sealed jars and exposed the jars to various temperatures to determine the relation of temperature to black heart and the dormancy period at which tubers are most susceptible to this disease. While the temperature factor gave extremely variable results, the authors concluded that potatoes are most

susceptible to black heart during the middle dormancy period and that large tubers are more liable to black heart than are small ones.

Further information on the best type of potato storage house to maintain proper temperature and humidity with a minimum of attention and a maximum durability of the storage structure has been reported by Edgar (5) of the United States Department of Agriculture. It was found that potatoes stored at 40° F. and at a uniform humidity suffer about one-half their total shrinkage during the first 30 days. Shrinkage for the first two weeks was 20 per cent below average if maintained at 56° to 60° and 20 per cent above average if held at 40° to 46° F. Special condensation surface walls are advised as a means of automatically controlling humidity without undue loss of moisture from the storage room and to preserve the wall materials from depreciation.

Recently the Michigan Experiment Station (8) in cooperation with the United States Department of Agriculture conducted tests to compare crates and boxes with bulk storage as affecting the amount of mechanical injury in stored potatoes. Percentage of injury was measured under both methods after the tubers had been run over a grader. It was found that injury ran as high as 16 per cent in bulk storage as against 1 per cent for tubers stored in crates and boxes. If not too impractical to store in boxes, it is suggested that this method will greatly reduce storage losses from bruising.

During the past year, Wright (23) of the United States Department of Agriculture reported on a study to determine the relation of previous storage temperature of potatoes to susceptibility to mechanical injury and to freezing, and chemical injury during transit. He found that whereas 31 per cent of those lots previously stored at 50° F. were injured, the injury was more than doubled in those lots stored at 32° F. Chemical injury occurred only where the tubers had been mechanically injured previously while freezing injury occurred independently of injury from bruising.

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PERFORMANCE OF CLONAL STRAINS OF TRIUMPH POTATOES

I. Triumph Strains on Dry Land in Western Nebraska

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In the early years of the seed improvement program (1916-1921) a great deal of variation was observed within fields of Triumph potatoes in western Nebraska with regard to size of vines, time of maturity, and set, size, and yield of tubers and intensity of tuber color. Early efforts to isolate and propagate clonal lines came to grief because of inroads of virus diseases. Following this experience, it was thought that these differences might be caused by some more or less masked forms of virus diseases, to the so-called "giant-hill" disease, etc. With the propagation of indexed tubers as tuber units in 1924 it became evident that great variation occurred within lots of potatoes free from virus disease and coming from the same field. The most apparent of these variations were visible as differences in vigor and time of maturity. These types continued in the various tuber lines from year to year. About 200 distinct lines were propagated from one lot of seed potatoes (1). As many of these variants differed only slightly with regard to time of maturity, the number of lines was reduced to eight and later to five. These represent the entire range of variation with regard to time of maturity.

These tuber-line strains have been increased through seed plats from tubers indexed annually to eliminate virus disease. Now thousands of acres of several of these strains of potatoes are being grown each year. The great variation once characteristic of western Nebraska Triumph potatoes has disappeared and the plants in large fields are strikingly uniform and the tubers much more uniform than formerly.

Just why these variations occurred in western[2] Triumph fields that traced back to stocks brought in from Wisconsin or Minnesota and why they did not occur in the Triumph stocks in these latter states is an interesting question. The author has frequently pondered the possibility of a relationship between the high potash content of these western soils and the high percentage of the radioactive isotope of potassium in potatoes, with the occurrence of these bud mutations in Triumph potatoes. Although there are many reasons to suppose that these stocks did not vary to this great extent when they were brought into these states,

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[2]Similar variation has also been observed by us in several stocks of Triumph seed from Montana.

we have had no substantiated evidence of mutations of this type having occurred in these clonal lines during the last fifteen years. During this time tens of thousands of acres have been inspected by seed certification inspectors who are well trained to detect variations. The situation presented may prove to be a fertile field for some investigator. During the last few years we have been concerned with the practical significance of these different clonal strains under the range of conditions where Triumph potatoes are grown commercially.

Extensive field tests of five or more of these strains were conducted during the last ten years in the various potato growing regions in Nebraska and with experiment stations in a number of southern and central states. From the physiological view point these locations presented a variety of environments in western Nebraska,—long hot days early in the season decreasing to short cool days with both abundant and scant moisture; in the south,—short cool days becoming longer and warmer; and in the corn belt—short cool days becoming very long and hot. Since these field tests did not give as clear-cut results as were anticipated, largely because of the great variation in temperature and rainfall from year to year and place to place, a series of tests was conducted in the greenhouse where day length, temperature, or nutrition could be varied as desired while other factors were reasonably constant. The results from these various tests are being presented in this series of papers.

As the Triumph variety has constituted more than 90 per cent of the commercial acreage of potatoes in western Nebraska during the last 10 or 15 years the importance of determining the merits of various strains for production under western dryland and irrigation conditions is obvious. In this region the main crop of potatoes is planted in mid-June and harvested in early October (3). During the early life of the crop the long warm or hot days are very favorable for vegetative growth if moisture is available. After the first six or seven weeks, conditions generally become very favorable for tuber formation, the days becoming cooler and shorter. It was under these conditions that the various types were detected and isolated.

The conditions in the vicinity of Alliance where the dry-land tests were conducted are typical of those prevailing throughout most of the dry-land potato regions of western Nebraska.[3] The altitude is approximately 4,000 feet, and the mean monthly temperature during the ten

[3]At various times throughout the conduct of this project in Nebraska the author has received valuable assistance from the following assistants or cooperators: W. E. McQuilkin, Marx Koehnke, Wm. Morrow, John Pospisil, Howard McLean, Philip Hoff, George Schmid, Chas. McCoy Quilkin, John McLean, Hugh Beal, Wm. Newman, John Nielsen, Gus Forsling, and Wm. Allington.

years of these tests ranged as follows: June, 63.9 to 74.1°F; July, 73.0 to 80.6°F; August, 67.5 to 76.4°F and September, 54.4 to 66.4°F as shown in table 1. The rainfall at Alliance is reported in table 2 as effective inches of rainfall occurring prior to and during each growing season.

TABLE 1—*Mean monthly temperature at Alliance during the four months of the ten potato growing seasons involved in the trials.*

Year	Alliance			
	June	July	Aug.	Sept.
1929	64.5	73.7	74.0	54.4
1930	65.2	75.7	71.7	62.3
1931	72.4	75.0	71.7	66.4
1932	66.7	74.3	73.2	61.6
1933	74.1	76.4	67.5	65.3
1934	69.6	77.5	72.8	55.7
1935	63.9	76.9	72.3	62.1
1936	71.5	80.6	74.9	63.2
1937	64.2	75.8	76.4	63.8
1938	67.4	73.0	74.7	64.7

Data from monthly reports of U.S.D.A. Weather Bureau.

TABLE 2.—*Inches effective rainfall at Alliance prior to planting potatoes and during each summer month. (Effective rainfall considered as comprising only that precipitation occurring at the rate of ½ inch or more in one day or two consecutive days.)*

Crop Season	From Previous Oct. 1 to May 31	June	July	Aug.	Sept.	Four Summer Months	Crop Season
1929	5.97	1.35	0.54	0.57	2.88	5.34	11.31
1930	11.25	0.51	1.89	2.32	0.80	5.52	16.77
1931	5.69	0.79	0	3.07	1.20	5.06	10.75
1932	2.84	1.62	0	1.92	0	3.54	6.38
1933	7.58	0	0.57	3.95	0.71	5.23	12.81
1934	1.61	1.21	0	0.63	0	1.84	3.45
1935	11.07	0.68	2.37	0.98	0	4.03	15.10
1936	1.11	2.33	0	0.57	0	2.90	4.01
1937	0.53	1.13	1.19	0	0	2.32	2.85
1938	7.80	1.69	2.29	0	2.58	6.56	14.36

Data calculated from monthly reports of U.S.D.A. Weather Bureau.

The crops of 1929, 1931, and 1932 were raised after a small-grain crop which undoubtedly left little or no available moisture in the subsoil. In all other years potatoes followed corn, after which subsoil moisture conditions were reasonably satisfactory except for the crop of 1937 (4, 5, 6, and 7) (see also tables 1 and 2). Grasshoppers, blister beetles, and jack rabbits did much damage from 1934 to 1938, with most severe

damage in 1937. Psyllids were serious in 1938 but were controlled reasonably well by prompt spraying.

When seed was held dormant until just before planting the emergence was more prompt with the early than with the late strains as shown in table 3. If seed was allowed to sprout there was little difference in emergence rate between strains.

TABLE 3.—*Average number of plants emerging by various dates per* 100 *seed pieces from two strains of Triumph potatoes planted at Alliance on two dates in* 1932.

Days after Planting	May 21 Planting		June 25 Planting	
	Very Early Strain	Very Late Strain	Very Early Strain	Very Late Strain
14	0	0	57	39
19	8	5	95	91
23	90	82	99	97
30	97	93	99	97

The number of stems per plant varied from year to year more than from strain to strain within the year. In seasons very favorable for early growth the number of stems was greatest with the earliest strain. In unfavorable years as 1931, the latest strain had most stems. In many years there was little difference.

Strain differences were not generally apparent in vine growth early in the season. The earliest strains appeared to show distinctly different leaf and plant characteristics about 90 days after planting in the case of early plantings or after approximately 95 days with late plantings. These differences consisted of a cessation of leaf differentiation and completion of growth by leaves in the apical whorl. This was followed by cessation of growth of lateral shoots, paler leaf color and the development of a glabrous leaf surface and rounded, less winged stems. The latest strains came into these same relative stages about 30 to 35

TABLE 4.—*Maturity of vines of two strains of Triumph potatoes planted at Alliance on two dates in* 1932. *Maturity estimated on all rows as percentage of ripeness of vines.*

Date of Observation	May 21 Planting		June 25 Planting	
	Very Early Strain	Very Late Strain	Very Early Strain	Very Late Strain
Aug. 8	45	7	0	0
Aug. 15	95	30	0	0
Sept. 1	100	92	0	0
Sept. 15	100	97	50	17
Oct. 1	100	100	98	45

TABLE 5a—*Test of five strains of Triumph potatoes at Alliance on dry land during ten seasons.*[1]

Triumph Strain or Variety	Year of Test: 1929		1930		Planting Date: 1931				1932				1933		
	May 27	June 24	May 20	June 27	May 21	June 4	June 15	June 26	May 21	June 6	June 17	June 25	May 25	June 5	June 15
	Harvesting Date: Oct. 5		Sept. 30		October 5				September 30				September 29		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Total Yield—Bushels per Acre															
V. Early	108	100	195	284	59	53	75	70	37	44	63	44	155	145	110
Early	128	109	207	317	62	51	80	78	34	60	65	48	164	161	103
Medium	109	115	216	324	68	52	84	80	43	71	59	48	168	164	92
Late	117	107	216	332	68	59	79	78	34	70	56	45	159	174	90
V. Late	131	111	244	331	70	56	76	73	27	74	59	49	160	175	89
S. Dif.	38.7**				6.1**		7.8**		29.4		8.8			13.4**	
		34.5**				17.3**		7.5**		13.6		4.0			71.4
U. S. No. 1 Grade—Bushels per Acre															
V. Early			19	134	35	19	46	49	7	12	22	8	26	9	53
Early			14	165					10	17	26	14	10	12	72
Medium			27	149	6	9	45	55	11	13	20	13	70	99	62
Late			20	166					6	14	18	9	94	90	63
V. Late			22	174	3	15	51	44	3	9	16	9	88	116	64
Percentage U. S. No. 1 Grade															
V. Early			10	47	60	36	61	70	20	28	36	11	17	6	53
Early			7	52					30	28	40	28	6	8	70
Medium			13	46	8	18	54	69	25	18	35	27	42	60	68
Late			9	50					18	20	33	19	52	52	70
V. Late			9	53	5	27	67	60	10	12	28	20	53	67	71

TABLE 5b—*Test of five strains of Triumph potatoes at Alliance on dry land during ten seasons.*[1]

Triumph Strain or Variety	Year of Test														
	Planting Date														
	1929		1930		1931				1932				1933		
	May 27	June 24	May 20	June 27	May 21	June 4	June 15	June 26	May 21	June 6	June 17	June 25	May 25	June 15	June 5
	Harvesting Date														
	Oct. 5		Sept. 30		October 5				September 30				September 29		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	Percentage Rough Tubers (knobs)														
V. Early			25	9	13	12	8	0		1	1		11	4	6
Early			18	8					2	2	1	1	11	8	6
Medium			17	10	43	33	30	0	6	6	1		9	6	6
Late			19	9					6	10	1	1	9	3	10
V. Late			30	7	35	25	13	0	5	13	1	1	11	6	6
	Percentage No. 2 Size (1-½" - 1-⅞")														
V. Early			12	3	7	38	19	22	36	37	30	36	5	8	8
Early			9	3					29	32	27	32	8	14	7
Medium			11	2	30	32	11	23	27	28	24	31	10	9	8
Late			10	2					27	24	23	27	8	8	5
V. Late			7	2	26	28	17	23	26	27	22	24	6	9	7
	Percentage No. 3 Size (Below 1-½")														
V. Early			7	2	11	15	12	10	43	32	30	43	3	7	5
Early			8	1					38	34	27	36	4	7	4
Medium			4	1	18	17	4	9	37	37	37	37	5	6	4
Late			6	1					47	39	40	50	5	6	4
V. Late			4	1	25	20	3	15	59	42	41	48	6	6	4

* F values exceed 5 per cent level, ** F values exceed 1 per cent level.

[1]Number of plats and plants per plat in tests of each year, parenthetical numbers indicate number of rows per plat when more than single row plats were used:

1929, 6-48
1930, 6(3)165
1931, 18-55
1932, 18-55
1933, 12-55
1934, 10(3)165
1935, 6-110
1936, 6(3)110
1937, 12-110
1938, 10-25

TABLE 5c—*Test of five strains of Triumph potatoes at Alliance on dry land during ten seasons.*[1]

Triumph Strain or Variety	Year of Test: 1934			1935				1936	1937		1938
	Planting Date: May 25	June 7	June 26	June 11		June 25		June 12	June 18	June 25	June 11
	Harvesting Date: September 18			Sept. 16	Oct. 1	Sept. 16	Oct. 1	Oct. 1	Sept. 29		Oct. 6
(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)
	Total Yield—Bushels per Acre										
V. Early	11	7	15	97	88	96	117	28	25	26	169
Early	8	4	12	96	105	117	135	27	21	23	202
Medium	7	5	18	102	105	116	131	27	19	23	
Late	6	4	12	96	103	118	133	25	17		
V. Late	6	4	11	94	114	113	148	26	17		
	2.7**	1.06**	2.2**					14.0**	9.2	9.3	21.2**
	U. S. No. 1 Grade—Bushels per Acre										
V. Early	11	3	8	43	37	68	77	9	4	3	116
Early	8	0	3	45	54	91	96	8	3	2	160
Medium	10	2	2	46	49	76	82	7	2	1	
Late	4	1	3	53	53	81	87	8	2		
V. Late	3	1	2	47	57	77	101	8	3		
	Percentage U. S. No. 1 Grade										
V. Early	10	5	6	44	42	71	66	31	27	17	70
Early	10	0	2	46	52	78	71	30	16	11	80
Medium	13	3	2	45	47	66	63	27	15	3	
Late	6	3	3	55	52	69	66	32	16		
V. Late	4	3	2	50	20	68	68	30	14		

TABLE 5d—*Test of five strains of Triumph potatoes at Alliance on dry land during ten seasons.*[1]

Triumph Strain or Variety	Year of Test														
	1934			1935				1936	1937		1938				
	Planting Date														
	May 25	June 7	June 26	June 11		June 25		June 12	June 25		June 18		June 11		
	Harvesting Date														
	September 18			Sept. 16	Oct. 1	Sept. 16	Oct. 1	Oct. 1	Sept. 29				Oct. 6		
(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)			(28)		
	Percentage Rough Tubers (knobs)														
V. Early	4			4	4	2	4	0	1	1			0		
Early	4			32	10	2	7	0	4	1			1		
Medium	3			11	10	6	6	0	4	1					
Late	0			10	11	6	7	1	1						
V. Late	2			14	14	7	6	0	3						
	Percentage No. 2 Size (1-½"-1-⅞")														
V. Early	25	13	19	27	26	18	11	31	32	24			18		
Early	17	11	10	17	17	12	9	30	24	20			10		
Medium	18	9	6	18	19	16	9	29	23	19					
Late	15	5	8	15	15	11	9	27	21						
V. Late	16	6	11	15	13	9	9	25	26						
	Percentage No. 3 (Size (Below 1-½")														
V. Early	62	82	74	25	19	8	5	31	50	65			11		
Early	67	89	91	16	13	6	4	40	58	71			8		
Medium	67	88	93	17	13	8	6	44	62	78					
Late	78	92	89	12	10	7	4	40	68						
V. Late	78	91	88	12	9	6	5	43	55						

days later or 120 to 125 days after planting. In some years, with late planting, there was no evidence of vine maturation with late strains up to the time of digging as reported in table 4.

In drought years the early-strain plants died down early but the late ones throve until finally they died of drought without being able to come into maximum tuber production as shown in table 5.

In the more favorable seasons (1929, 1930, 1933, 1935, 1938) there was a definite trend in the direction of highest total yields from the later strains and lowest yields from the earliest if plantings were made before the middle of June. With late-June plantings the yields from the later strains were frequently lower than those from the earlier strains. However, during the extraordinarily favorable year of 1930 the late strains outyielded the earlier ones even when planted on the 27th of June.

In the fairly dry years of 1931 and 1932 there was a shortage of subsoil moisture because of potatoes having followed small grain. Under these conditions yields of late strains were either about the same as from the earlier ones or they were lower.

In the severe drought years of 1934, 1936, and 1937 yields were very low, although all these crops followed corn (which left more moisture in the soil than did small grain), there was, however, some subsoil moisture deficit. Insects and jack rabbits also did more than the usual amount of damage. In these dry years yields from the earliest strains were highest and those from the latest strains were lowest, but as all yields were very low, differences were of course very small.

In the good years, yields of U. S. No. 1 potatoes were greatest with the later strains, but in the dry years the early strains were very definitely more productive than the late ones.

The yield from midseason strains was superior to that from the earlier ones in the good season of 1930. During years when the latter part of the season was dry, as in 1933 and 1935, the yields of midseason strains exceeded those from the second early only a trifle when planted early. With later plantings the yield of midseason strains were lower.

The very late strains generally outyielded the midseason strains except in the exceedingly dry years or seasons that were dry at the end. From season to season there was a vast difference in percentages

of the various types of defects, but these were influenced more by season than by strain difference. Very consistently the latest strain had a lower percentage of second grade size tubers but a higher percentage of cull size than the midseason strain.

The percentage of first grade potatoes was probably influenced more by season and time of planting than by strain characteristics. In the favorable growing seasons the percentage of first-grade potatoes was greatest with the late and least with the early strains. With adverse seasons the percentages of first grade tubers were low, those of the earlier strains being the highest and late strains the lowest.

In the seasons of good rainfall potatoes failed to meet grade No. 1 requirements because of scab, excess size, roughness (knobs, growth cracks, elongated tubers, etc.), harvest cracks or digger cutting, but in dry years all these factors were of little or no consequence, as defects in comparison with prevalence of small size tubers.

When conditions were favorable for high yields, not only did the late strains yield the highest but the tubers of these strains were the largest. These data are given in table 6. In the drier years they were smaller as shown by the tuber-size distribution tables. Before these tubers line strains were isolated, the proportion of the various types in a commercial lot of potatoes was constantly changing. For example, if small tubers had been used from the 1929 crop for planting the next crop, the percentage of late type plants would have increased but with the 1930 crop the selection of small tubers would have brought about a slight increase in the early strains. As an example of this, when tubers weighing 50 to 75 grams are considered the following condition would have occurred in 1929 and 1930:

	1929 (50-75 Gm. Size)		1930 (50-75 Gm. Size)	
	Per Cent of Tubers	Bu. per Acre	Per Cent of Tubers	Bu. per Acre
Very early strain	11.1	11.1	3.7	10.5
Very late strain	26.2	29.2	2.6	8.6

TABLE 6.—*Percentage of tubers of various weights produced by three strains of Triumph potatoes.*

Weight Range of Each Group (Grams)	Planted May 27, 1929			Planted May 20, 1930			Planted June 27, 1930		
	Very Early Strain	Mid-Season Strain	Very Late Strain	Very Early Strain	Mid-Season Strain	Very Late Strain	Very Early Strain	Mid-Season Strain	Very Late Strain
0-25	3.0	1.9	2.9	0.6	0.4	0.2	1.6	0.1	0
26-50	6.8	8.5	14.6	8.0	6.5	4.1	1.6	1.4	0.9
51-75	11.1	17.6	26.2	11.7	11.4	6.9	3.7	3.1	2.6
76-150	49.0	54.9	49.8	44.5	39.6	29.5	22.1	18.7	22.2
151-225	23.4	13.7	5.8	25.0	30.8	29.5	28.5	25.9	28.1
226-300	6.8	3.3	1.1	8.3	6.8	18.6	20.8	25.2	22.0
Over 300	—	—	—	2.9	4.4	11.3	23.2	25.8	24.0

With the selection of large tubers the early strain would have increased most after 1929, whereas after 1930 such selection would have resulted in a slight increase in late types. After years of early frosts, the use of small seed tubers undoubtedly increased the percentage of late types.

When moisture conditions were relatively favorable as in 1930, 1933, and 1935 the percentage of rough potatoes was quite high because of brief drought periods or periods of excess heat during which the rate of tuber growth was greatly diminished only to increase rapidly with the advent of favorable temperature or rainfall. If the check in growth occurred when tubers were quite small most of the second growth occurred as "bottle necks" or elongated tubers caused by the expansion of the apical end and more or less lack of expansion of the basal end. If tubers were fairly large when growth was checked and resumed, second growth generally occurred as bulging eyebrows or knobs. If the resumption of growth was very abrupt, growth cracks, often of great severity, occurred with these Triumph potatoes. In the dry seasons there was little opportunity for growth resumption. The slight amount of second growth that occurred was generally of the bottle-neck or elongated tuber type, the latter sometimes difficult to distinguish from spindle-tuber. The earlier plantings always produced more rough tubers than the later ones.

The relative percentage of rough tubers produced by the several strains varied a great deal as a result of the differences in tuber development, plant vitality, etc. when periods of stress and favorable conditions occurred. Generally the earlier strains had the fewest rough tubers. Although differences were not consistent, it can be said that the percentages of rough tubers from the various lines formed an increasing gradient from the earliest to the latest strains. The tubers of late-type strains were as a whole more elongated than those of early strains as shown by W/L ratios of 1929 and 1930. When classified by tuber size in 1930 the smaller tubers of late types of each strain were more nearly rounded than the smaller tubers of the early strains but the very large tubers were slightly more elongated. The smaller tubers of the late strains developed in cooler weather than those of the early strains. With the late strains the larger tubers set quite early and developed over a long period of irregular weather.

Scab occurrence was influenced about equally by season and planting time as recorded in table 7. The percentage of scabby tubers was high in the two most favorable potato seasons, whereas in the dry years it was not a factor. Scab was always most severe with early plantings,

decreasing with each successively later planting. In order to escape scab with the earliest strains it was necessary to plant later than the 15th of June. When scab was severe it was always most prevalent with the earliest strains.

TABLE 7.—*Percentage of scabby tubers produced with different strains of Triumph potatoes at Alliance during two years when scab was serious.*

Strain	1930 Date Planted		1933 Date Planted		
	May 20	June 27	May 25	June 7	June 26
Very early	51.1	4.2	61.7	74.3	21.5
Early	46.0	2.6	69.3	62.9	2.5
Mid Season	44.0	2.9	34.4	15.6	1.0
Late	40.8	1.7	19.0	20.1	0
Very late	38.4	1.0	25.1	16.9	2.1

1930 crop harvested Sept. 30: 1933 crop Sept. 29.

Some strains of fairly similar growth habit did show quite distinctive differences. The second or early strain outyielded the first or very early strain in all except the drought years. In yield of No. 1 tubers they followed the same trend, the position of the second-early strain being still further improved in good years because of a higher percentage of No. 1 tubers resulting mostly from a lower percentage of scabby and small tubers. The very earliest strain commonly had the lowest percentage of rough tubers and as a whole the tubers were of best type. This indicates that on good soils reasonably well supplied with moisture the very earliest strain may yield the nicest looking crop of tubers and in dry years it is superior. It is, however, to be considered of limited value for dry-land growing because of low yields in many years. Because of the small size of the plants of the earliest strain the total yield might be improved by planting more closely.

Cracking of tubers at harvest time was extremely severe in some seasons but was not noticed in others. In fact in some seasons it was impossible to crack any tubers except by shocks much more severe than those encountered with the most careless harvesting methods. Cracking at harvest time seemed much more severe with late than with early plantings. These results are given in table 8. The strain differences are sometimes confusing in that sometimes tubers from early strains crack more severely than those from later strains. Very mature tubers do not crack severely, and very immature tubers do not crack so severely

as partly mature tubers. Very immature potatoes seem somewhat resilient and although the skin may rub off because of rough handling the tubers may not crack. That explains why the potatoes from late plantings of some late strains cracked less than those from some of the earlier strains or earlier plantings.

TABLE 8.—*Percentage of tubers cracking in harvesting during three seasons when cracking occurred to a serious extent at Alliance.*

Strain	1930 Date Planted		1933 Date Planed			1935 Date Planted	
	May 20	June 27	May 25	June 5	June 15	June 11	June 25
Very early	3.7	20.8	0.6	0.3	6.6	1.7	6.4
Early	3.1	21.8	1.0	0.6	9.0	3.0	3.9
Mid Season	9.3	20.2	0.1	2.0	1.8	4.0	8.8
Late	4.9	22.3	0.3	0.7	8.5	4.0	6.8
Very late	4.4	22.7	0.3	0.5	8.1	5.0	4.3

Harvested 1930 crop Sept. 30; 1933 crop Sept. 29; 1935 crop Oct. 1.

Oversize tubers, those over 3¼ inches, are not desired for seed purposes, and except for special markets are not especially desirable for the table market. Such large tubers were prevalent only in 1930. During this season they did not occur to a serious extent with the early planting but they amounted to 10 per cent with late plantings. The midseason strains appeared to have most oversize tubers, and the latest strains the fewest.

In spite of caution many Triumph potatoes may be cut by the digger because of the depth of tubers or the distance from the center of the row. Cutting seemed to have been most severe with the later plantings, the tubers apparently having set on longer stolons than those of earlier plantings. Tubers of the midseason and late strains appeared to suffer most liability of cutting but the tendencies were very irregular.

Number two size tubers (1⅞ to 1½" diameter) have a good market value since they are considered very desirable for seed purposes. However, at present they are not so desirable economically as larger or No. 1 size tubers. There was a trend for earliest plantings to produce most No. 2 size tubers especially in dry seasons. The percentage of No. 2 size tubers was quite consistently highest for the earliest strain and lowest for the latest as shown in table 5. Thus when strains are mixed in a lot of seed, the use of No. 2 size seed will tend to increase the percentage of early-strain plants.

Number 3 size tubers (below 1½ inches) were more prevalent than any other size in dry years. In years below the average they constituted a higher percentage than the No. 2 or No. 1 size (by weight)

but in good years they were a minor factor. In good seasons and in most dry and drought years, percentages of No. 3 size tubers were highest with early plantings. The strain relationship varied, but most frequently the later strain had the high percentage of the No. 3 size tubers.

In the 1931-'32 storage season the tubers of early strains lost less weight in storage than late strain tubers. The less mature the tuber, caused by late planting, the greater was the increase in the loss of the late as compared with that from the early strain.

Conclusion

Even though differences in strains vary a great deal from year to year, there seem to be a few important consistent differences.

Under the conditions at Alliance with dry land culture, yields have been greatest with the later strains in all years except the very dry or drought years. Early types have produced the smoothest best type tubers that generally cracked slightly less at harvest time. Early strains almost always yielded more No. 2 size tubers, but the late strains generally produced the greatest number No. 3 size tubers.

Apparently the earliest and latest are not the most desirable strains. The midseason strains seemed the most suitable for tuber production under the range of conditions that occurred. During the ten years of these tests climatic conditions varied from one extreme to another as much as they have varied during the last 50 years.

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REPORT OF THE COMMITTEE TO COORDINATE RESEARCH ON NEW AND UNUSUAL POTATO DISEASES[1]

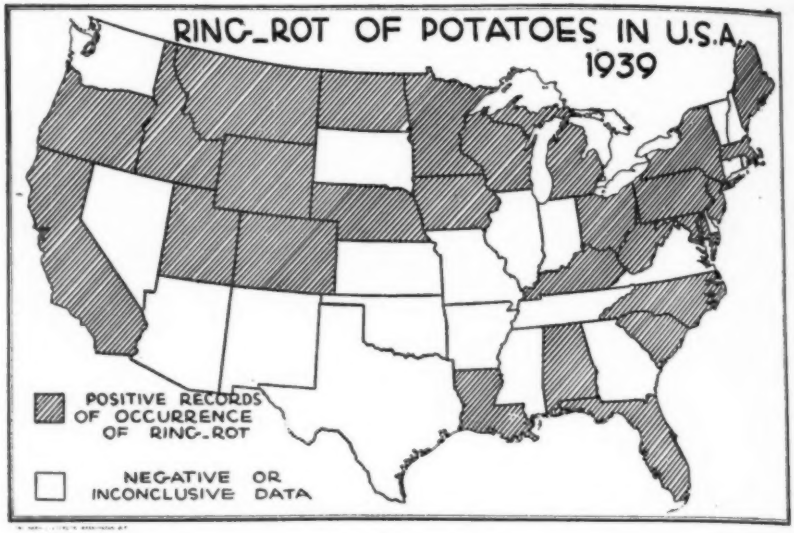
INTRODUCTION

At the Richmond meeting last year the Society appointed a committee charged with the task of coordinating research on certain new and unusual potato diseases. Your Committee felt that it could best serve this purpose by first making a survey to determine the extent of the occurrence of these diseases in the United States. Accordingly, plans were made for a nation-wide survey to determine the prevalence of bacterial ring rot and the so-called purple top wilt or blue stem. At this point the Committee wishes to acknowledge the very willing and helpful cooperation of the plant pathologists of all of the State Experiment Stations, the Potato Certification officials and officials of the various State Departments of Agriculture. The Committee also has received the very helpful cooperation of the staff of the Plant Disease Survey of the United States Department of Agriculture and of Dr. R. J. Haskell, Extension Pathologist of the United States Department of Agriculture.

RESULTS OF THE SURVEY

Because of the difficulty of definitely identifying purple top wilt or blue stem, and because the etiology of the disease is not definitely known, the survey for this disease was not very successful. This report, therefore, will deal mainly with the survey for ring rot. The accompanying map presents in graphic form the results of the survey for this disease. It will be noted that ring rot has been reported definitely from 27 states. Negative, in-

[1]Paper presented at the 26th Annual Meeting of the Potato Association of America at Columbus, Ohio, December 30, 1939.



complete or inconclusive reports have been received from the remaining 21 states. No attempt has been made in this map to show the distribution of the disease within individual states. A state shaded in the map merely indicates that the disease has been reported from at least one locality in the state. The negative reports do not necessarily mean that the disease does not occur in the state, for in most cases the cooperators have indicated that a very thorough survey had not been made. The survey has served to confirm earlier expectations that the disease would prove to be very destructive. Those who have observed the disease in regions where it is very prevalent uniformly agree that ring rot is a real threat to potato growing in this country. The following quotations are from letters received by the Committee in the course of the survey:

1. "The loss was about 20 per cent in one field planted with certified seed."

2. "The loss in one county is estimated at 500 to 700 cars plus reduced price on several thousand cars."

3. "Many fields showed large amounts of this disease, infection in some cases reaching 100 per cent."

4. "Tuber rot was very prevalent in 1937 and 1938, the estimated loss being about 25 per cent."

5. "In one county the growers are becoming very discouraged because of serious losses. Potato acreage and production have declined 50 per cent in the past three years."

6. "Percentages range all the way from a trace in some fields up to 30 and 40 per cent in others."

7. "My opinion of the economic importance of ring rot in this state is that it will become one of our major diseases. We are amazed at its rate of spread in some of our experimental plots."

8. "Unless drastic measures are taken against contaminated seed stocks, it seems possible that the disease may become a menace to potato growing in this state."

9. "One grower indicated that he was likely to lose about $10,000 from ring rot. This fall I learned from fairly good authority that the actual loss was about $4,000."

10. "Ring rot is of major importance in this state. The loss in 1939 was probably $250,000."

Another point of considerable significance is the almost unanimous opinion of those who cooperated in the survey that the disease had been introduced into their state on seed stock that had been brought in from some outside source. Although largely circumstantial, there is a great deal of evidence that the disease has been introduced into the United States within relatively recent years or else it has suddenly become much more virulent. The former alternative appears more probable. It does not seem possible that a disease of this nature could have been present for very long without having been observed. If this conclusion is correct, we may expect the disease to become more widespread within the next few years unless some effective means of checking its spread is discovered and put into operation at once.

When we give careful consideration to the facts brought out by this survey it is obvious that the occurrence of this disease has a great deal of significance to the Potato Certification industry. There is evidence that it has been distributed from place to place on certified seed as well as on non-certified seed. This places an urgent responsibility on the Certification industry to eliminate the disease from its seed stock if it is to maintain the reputation that has been built up by much effort during the past 25 years. Last year this Society went on record as recommending the adoption of a zero toleration of this disease by all certifying agencies. This recommendation has been adopted by most states, but the application of the rule has necessitated the rejection of an unusually large number of fields inspected for certification. This has naturally worked a great hardship on growers of certified seed and there has been some agitation for liberalizing this tolerance. Many states

have laws requiring that all seed stock offered for sale as such be certified. Some have argued that a rigid enforcement of the zero toleration would limit the available supply of certified seed much below the demand and result in the planting of increased quantities of inferior non-certified seed. This Committee has no data on this point, but it feels that the zero tolerance should be maintained until every possible effort has been made to eliminate the disease from seed stock, and until it has been shown that this cannot be done without seriously handicapping the potato industry. Some states already are discussing the possibility of prohibiting the importation of certified seed, requiring growers to use home-grown seed. If the potato growers continue to suffer losses from ring rot in fields planted with certified seed, the certification industry is likely to receive a setback, recovery from which will require many years of patient effort.

In view of the known facts about ring rot it seems advisable to emphasize the importance of bin inspection in detecting the disease. In some regions where virus diseases have been the only diseases of much importance in certification, bin inspections have been neglected or entirely omitted. It is suggested that certification officials give due consideration to this method of detecting the disease.

The possibility of introducing ring rot into new localities on seed stock shipped from state to state for experimental purposes should not be overlooked. Every potato research worker should recognize this danger and use all the safeguards possible.

Another point of considerable interest is the ultimate disposition of the seed stock from those fields submitted for certification but rejected because of small percentages of ring rot. It has been reported to your Committee that in some cases this stock is sold and used for seed purposes but not as certified seed, the purchaser being willing to take the chance on a small amount of ring rot, provided the seed is of high quality in other respects. Such a practice, if it becomes general, may defeat the purposes of control through certification.

Although much of the responsibility for controlling this disease will fall upon the certification industry, an equal if not greater responsibility will fall upon the research worker, for at the present time we do not have sufficient information on which to base an intelligent control program. Because of the critical nature of the problems raised by the presence of this disease, an experimental basis for control is urgently needed, and an adequate research program should be carried out as soon as possible. Because of the widespread prevalence of the disease, the problem is not a local one, and should be investigated in as many parts

of the country, and attacked from as many angles, as possible. Research workers in several different states have indicated their intention and desire to conduct research in this field, and several important contributions have been made at this meeting. This Committee will be glad to aid in the exchange of information or do anything else that it can to further an adequate program of research, but since the National Potato Project of the United States Department of Agriculture has adequate machinery and facilities for coordinating such a program, this Committee feels that it is the logical agency for this service. The Committee can be most effective by representing the Society in an advisory capacity.

There has been some confusion in the common names used to designate this disease. It has been called bacterial wilt, bacterial wilt and soft rot, ring rot, etc. Because of the danger of confusion with bacterial wilt (*Phytomonas solanacearum*) and soft rot (*Erwinia carotovora*) this Committee believes that it would be desirable to adopt a uniform name; and it believes that "ring rot" or "bacterial ring rot" (a direct translation of the German "Bacterienringfäule") is perhaps the most suitable common name for the disease caused by *Phytomonas sepedonica*.

The Committee has considered the available information about the nature of ring rot, its method of spread and possible means of control, and it takes the liberty of suggesting a few problems that are in need of immediate attention:

1. A number of years ago several workers investigated the relative value of disinfecting seed tubers before and after cutting. At that time ring rot was not a problem, and the conclusions were generally in favor of treating the seed before cutting. It appears that with the appearance of ring rot the entire question has been reopened. Because of the apparent ease with which ring rot is spread by means of the cutting knife, the disinfection of cut seed pieces offers a promising means of control. Some of the newer fungicides may be well adapted to the disinfection of cut seed pieces without the usual seed injury.

2. The opinion appears to be rather prevalent that the pathogene of ring rot does not survive in the soil. However, because of the wide variation in environmental factors in different sections of the United States, it is highly desirable that this question be investigated further. We have practically no experimental evidence for the general assumption that the organism will not survive in the soil.

3. Our evidence on the spread of the disease in the field also

is conflicting and inconclusive. It is imperative that we know the extent of field spread and if the disease is spread in the field what agencies are responsible.

4. European workers have stressed the value of planting whole tubers instead of cut seed pieces as a control for ring rot. A number of years ago this practice was discouraged in this country because of the increased probability of using virus-infected tubers when small tubers were selected for seed pieces. With the increased efficiency of virus disease control through certification, this objection appears no longer well founded. If ring rot continues to be a factor, the practice of using whole small tubers for seed purposes may be desirable.

5. The relation of volunteer plants to the overwintering of a pathogene in the field should be investigated. There is some evidence that very slightly affected tubers do not rot in storage and upon planting may transmit the pathogene. Similar tubers surviving in the soil during the winter may be of considerable importance provided field spread occurs.

6. All available evidence indicates that the pathogene is *very* highly infectious which would give added importance to the disinfection of containers, storage houses, as well as planting and grading machinery.

7. Several workers have reported to the Committee that it is difficult to detect the infection, both in plants growing in the field and in tubers in storage. Infected plants or tubers may show almost no injury, yet the tubers may produce badly infected plants. If seed certification is to be effective, a more accurate method for detecting infection is highly desirable. Investigations of this aspect of the disease might yield results of great importance in ring rot control.

Educational Problems

Effective control of ring rot will depend not only upon certification practices and the research program, but will depend also on the effective education of the individual grower as to the danger of ring rot. It has taken many years to educate potato growers to an appreciation of the control measures that have been recommended for the older and better known diseases. If the control of this disease is going to necessitate radical changes in our control program, we cannot expect the general farmer to adopt this change without an intensive educational program. We must not forget also that certified seed constitutes only a small proportion of the potatoes that are planted. Much seed stock consists of potatoes sold for table stock, and the control of the disease in fields

where certified seed are not used is going to present a difficult problem. The extension workers in plant pathology will face the problem of presenting new control measures and educating the farmer to a point where he will put them into practice. Because our present control program is only tentative and will probably be modified by the results of research, the extension worker must be constantly ready to modify his recommendations as the experimental evidence justifies.

Conclusions and Recommendations

By way of summary your Committee offers the following conclusions and recommendations:

1. Ring rot is widely distributed in the United States, but distribution is local in most states.

2. Circumstantial evidence indicates its probable recent introduction and spread throughout the country. Much of this spread can be traced to certified seed. We may expect continued spread in the next few years unless effective measures of control are discovered and put into effect very soon.

3. The disease is highly infectious and has been extremely destructive in certain localities, and is potentially destructive wherever it occurs.

4. The Potato Certification agencies have a grave responsibility in preventing further spread and also in the control of the disease. The Certification industry must be expected to make some sacrifices in the way of strict tolerance to ring rot unless new evidence justifying more lenient regulations becomes available. It is the opinion of this Committee that the zero tolerance for ring rot should be continued until more information is available to justify its removal.

5. There is urgent need for research leading to effective control of ring rot. The problem is nation wide, and because of the variation in climatic conditions under which potatoes are grown, research should not be confined to a few localities. It is the recommendation of this Committee that as many agencies as possible undertake research on the problem. Duplication of some phases of the work and confirmation of results will hasten final conclusions and is desirable.

6. An intensive educational program should be carried out by extension workers to acquaint the potato growers with the dangerous nature of the disease and to further the use of the best control measures available.

7. It is recommended that all research workers recognize the danger of introducing the disease on seed stock used for experimental purposes and use all precautions to prevent such spread.

8. For the sake of uniformity and to avoid confusion it is recom-

mended that the common name "ring rot" be adopted for the potato disease caused by *Phytomonas sepedonica.*

9. In conclusion the Committee expresses its appreciation to those who have cooperated in this survey and offers its services to all agencies interested in fighting the disease on a national scale. It recommends that all interested parties cooperate in every way possible with the National Potato Project in its fight against ring rot.

Respectfully submitted,

T. P. DYKSTRA,
R. W. GOSS,
J. G. LEACH, *Chairman.*
Committee to Coordinate Research on New and Unusual Potato Diseases

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THE COPPER CONTENT OF LONG ISLAND SOILS IN RELATION TO TUBER ROT OF POTATOES CAUSED BY *Phytophthora infestans* (Mont.) deBary

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In certain sections of Long Island nearly every year conditions of temperature and humidity are favorable for the development of epiphytotics of potato late blight caused by *Phytophthora infestans.* Although the foliage blight may be very severe, the incidence of tuber rot during a period of years, has been observed to be negligible. This has been most strikingly apparent in fields in which improper spraying has permitted foliage blight and the gradual dying of the plants, with the result that an abundant and continued supply of sporangia has been introduced into the soil. The amount of tuber rot even under these extreme conditions has been very small, as is shown in table 1. The present paper relates to an investigation undertaken to determine, if possible, what factor or factors might be responsible for the apparent absence of tuber rot under these conditions.

One of the first possibilities which appealed to the writers in this regard was the accumulation of copper in the soil in quantities sufficient to inhibit the development of the organism. Such an accumulation of

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TABLE I—*Effect of Bordeaux Mixture spray schedule on the incidence of foliage blight and tuber rot caused by P. infestans*

Bordeaux Mixture Schedule	Aver. No. of Blight Lesions per Hill	Aver. No. of Leaflets per Hill	Amount of Tuber Rot
2-1-50	21.1	274.3	None
4-2-50	8.4	431.8	None
6-3-50	6.1	423.3	None
8-4-50	3.4	408.5	None
Check (Unsprayed)	Plants dead		None

copper might result from continued spraying with bordeaux mixture over a period of years. To determine whether copper in the soil might be a factor, germination of sporangia of *P. infestans* was tested in water in which these soils were suspended. These soils were then also analyzed for copper content.

METHODS

Randomized soil samples were collected from fields in which potatoes had been grown for several years as well as from fields never planted to potatoes. These are termed, for purposes of discussion, respectively "Old" and "Virgin" soils. Small but equal amounts of the two soils were placed on glass slides and distilled water added until a film surrounded the periphery of the soil samples. Sporangia were then introduced into the film of water and subjected to proper temperature conditions for germination. Samples of the same soils used in the tests for sporangial germination were also analyzed for total and replaceable copper. Total copper was determined electrolytically from an ashed sample dissolved in concentrated nitric acid. Replaceable copper was that copper replaced by 1,500 ml. of normal neutral barium acetate from a 50-gram sample of soil.

EXPERIMENTAL RESULTS

About ten fields were first analyzed for total copper. These included nine so-called "Old Soils" and one "Virgin" soil. The various old soils have been used for potato culture for periods varying from 18

to 32 years. The copper content of these fields was found to vary from 66.5 to 90.5 parts per million of metallic copper, as revealed in table 2. The "Virgin" soil was found to have a rather high content of copper. This particular field was unfortunately so situated that there was a possibility of water run-off from adjacent fields and some copper may have been carried over in this form. In general, however, the tendency was towards higher amounts of copper in those fields in which the potatoes had been sprayed the most frequently.

TABLE 2—*Analyses of Long Island soils for copper content.*

Soil Sample		Total Metallic Copper		Replaceable Copper	
Source of Soil	Field No.	In P.p.m.	Lbs. per Acre	In P.p.m.	Lbs. per Acre
"Virgin" soil	10	10.3	20.3	1.4	2.8
"Old" soil	1	69.6	139.2		
	5	81.9	163.8		
	6	66.5	133.0	6.1	12.2
	7	90.5	181.0	9.0	18.0

For those samples in which replaceable copper was determined it is interesting to note that the quantity of replaceable copper is usually about one-tenth that of the total copper.

For tests on germination of sporangia soil samples from fields 10 and 7 were selected, particularly, because their spraying history was known. Field No. 7 has been used continuously for potato culture for 32 years, whereas field No. 10 has never been planted to potatoes. The average germination of sporangia from 24 tests on "Old" and "Virgin" soil is presented below in table 3, together with the copper analyses of these same soils.

TABLE 3—*Germination of sporangia of P. infestans in water suspensions of "Old" and "Virgin" soils and copper analyses of these soils*

Source of Soils	Percentage Germination of Sporangia of *P. infestans*	Metallic Copper in Parts per Million	
		Total	Replaceable
"Old" soil	50.4*	90.5	9.0
"Virgin" soil	8.6	10.3	1.4

*Germination in distilled water 65.4 per cent.

It is to be noted that good germination of the sporangia was obtained in the film of water surrounding the "Virgin" soil sample, and that germination was practically inhibited in the case of the "Old" soil. It would have been better if records could have been obtained on the germination of swarmspores. The prevalence of soil particles, however, made this impracticable.

Discussion

This particular "Old" soil under discussion has been used continuously for potato culture for the last 32 years. During this time approximately 640 pounds of metallic copper per acre have been added in the form of bordeaux mixture. Calculating from our analyses for total metallic copper and assuming 2,000,000 pounds of soil per acre to a depth of 6 inches, we can then roughly estimate that there is at present a total of 180 pounds of metallic copper per acre in this same soil. This would indicate that approximately one-third of the copper applied still remains in this soil. Whether such quantities are injurious at present, or will in the future accumulate to a point injurious to potato culture remains a point of conjecture.

The use of the recommended bordeaux mixture has not resulted in any marked increase in yield in certain sections of Long Island except in years of heavy insect infestation and/or late blight outbreaks. This is contrary to the results obtained in Up-State New York where marked increases in yield are consistently obtained even in the absence of disease or insect infestation, *i. e.* a marked stimulatory effect results from the use of bordeaux mixture (Blodgett *et al.* 1933). Within the last few years the growers on Long Island have reduced the number of applications of bordeaux mixture per year from approximately 10 to approximately 4 or 5, *i. e.* to a point where applications are made only in the event of insect or disease outbreaks. This is particularly true of those areas on Long Island in which late blight epiphytotics occur about once in 5 or 6 years.

Although other soil factors may be operative in inhibiting swarmspore development and, in turn, reducing tuber rot, this preliminary work is at least suggestive that accumulated copper in the soil may be an important factor in accounting for this apparent lack of tuber rot. This is also probably related to the interesting observation that tuber rot is quite apt to be serious in soils planted to potatoes for only a short while and which have been sprayed only two or three years. There is

also the interesting fact that such tuber rot as does occur in "old" soils is usually confined to tubers close to or on the surface of the ground.

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POTATO BREEDING FOR FUSARIUM RESISTANCE

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For the past ten years a potato breeding program has been conducted at Greeley, Colorado. During this time one of the principal problems has been the breeding of potatoes for Fusarium resistance; with 150 or more seedling varieties included in the test each year.

Fusarium wilt is one of the major potato diseases of the region, and is very common in the commercial fields. A survey of the potato growing areas of Colorado made during the period 1930-1935 showed that both *Fusarium oxysporum* and *F. eumartii* are present in potato fields and cause wilt. *Fusarium eumartii* was found to be more prevalent early in the growing season when the potato plants were small and *F. oxysporum* more common as the cause of wilt in late season during the period of high soil temperatures. During the 5-year period, the presence of the two Fusarium species in potato stems was about equal. *F. oxysporum* was found to be more limited to the warmer soils, whereas *F. eumartii* was readily isolated from potato stems growing in the cooler soils of the high mountain valleys. The severity of the disease is governed largely by the growing conditions during the months of August and September.

During the first few years when field tests were conducted, the po-

TABLE 1—*Comparative Fusarium readings of vines and yield of tubers of some of the very susceptible and more tolerant varieties of potatoes for the years* 1938 *and* 1939, *Greeley, Colorado*

Variety or Seedling	Rating of Vines[1]								Rating of Tuber Yield[2]							
	1938				1939				1938				1939			
	Plots				Plots				Plots				Plots			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
2135	1	2	2	2	0	1	0	1	4	3	4	3	5	5	4	5
47053	2	1	2	2	1	1	1	0	4	3	4	2	3	2	3	3
2134	.	.	.	.	2	1	1	0	.	.	.	.	5	5	4	5
1221	2	2	2	2	2	1	1	1	2	3	3	3	2	2	3	2
110	3	3	3	4	2	3	3	4	2	2	2	2	2	3	3	4
Katahdin	3	3	3	3	1	2	2	1	2	2	3	2	2	2	3	3
Rural	3	4	5	4	5	5	3	1	2	3	2	2	0	0	2	2
Triumph	5	5	5	5	5	4	3	3	2	2	2	2	0	1	2	2
Earlaine	4	4	5	5	5	5	4	4	1	1	1	2	0	1	1	2

[1]Figure 5 indicates severe fusarium symptoms on the vines of all plants, whereas o indicates lack of symptoms on all plants.
[2]Figure 5 indicates large yield at time of harvest, 1 indicates very small yield and o indicates no tubers.

tatoes followed either alfalfa or potatoes. The soil was irrigated late in the season or it was allowed to become dry between the first and second irrigations in order to produce unfavorable growing conditions. Seedlings grown under these conditions usually produced wilt symptoms. However, comparatively few were entirely killed by wilt. In 1936, the fusarium test plots were planted on a one-acre tract of land that had produced potatoes continuously since 1932. Since that time the tests have remained on the same tract of land, except in 1939 when a number of the plots were located on adjoining land that had produced a crop of potatoes the previous year.

The table presents some very interesting results. It will be noted that Rural New Yorker and Triumph, the two check varieties, and Earlaine are very susceptible to fusarium wilt and the yield of tubers is very low. The disease readings of Seedlings 2135 and 47053 indicate only a slight infection of the vines and a good yield of tubers. Seedling 2135 gave similar results in 1937, but Seedling 47053 was not included in the test that year. Seedling 2134, of the same parentage as Seedling 2135, gave similar disease readings in 1939 and produced a good yield of tubers.

Seedlings 1221, 110 and Katahdin showed more severe vine injury

FIGURE 1.—Fusarium resistance test plots showing susceptible and tolerant varieties. The more vigorous plants in the left foreground are from Seedling 110. (Photograph taken on the 25th of August, 1939).

and a smaller yield of tubers than Seedlings 2135, 47053, and 2134, but much less vine injury than Rural New Yorker, Triumph and Earlaine.

In previous tests at Greeley, Katahdin, Rural New Yorker and Triumph gave results similar to those for the years 1938 and 1939. Of the hundreds of seedlings that have been tested for fusarium resistance, some have been more susceptible than the Rural New Yorker and Triumph, whereas many others have shown some tolerance. Although Seedling 2135 has shown only slight vine symptoms of fusarium and produced good yields of tubers, this seedling cannot be introduced for commercial plantings because the flesh is tinged with red, a very objectionable feature in a commercial variety. Seedling 110, which may soon be introduced, has a record similar to that of Katahdin. Figure 1 shows a photograph of one plot of this seedling taken on the 25th of August, 1939. The vines show considerable vigor, whereas the vines of some of the more susceptible seedlings have been killed.

These tests indicate that it may be possible to develop commercial varieties of potatoes with a high degree of resistance to fusarium in the field.

PERFORMANCE OF CLONAL STRAINS OF TRIUMPH POTATOES
II.
COMPARISON OF STRAINS UNDER IRRIGATION CONDITIONS IN WESTERN NEBRASKA

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In the North Platte Valley where potatoes are grown as a late crop, midsummer temperatures are high but the short cool days of late summer and early fall, together with a generally adequate supply of irrigation water, provide excellent conditions for rapid tuberization. (For temperature during testing seasons see table 1.)

The tests under irrigation conditions were conducted on the Scottsbluff experiment farm (altitude 4,000 feet) for a period of 7 years.[2] Potatoes were planted or harvested on several dates during some of the

[1]Published with the approval of the Director as Paper No. 239. Journal Series, Nebraska Agricultural Experiment Station.

[2]The author was assisted at various times by James Holden, Lionel Harris, Chas. McCoy, Phillip Hoff and Louis Knoflicek.

TABLE 1.—*Mean monthly temperature at Scottsbluff during the four months of the eight potato growing seasons involved in the trials.*

Year	June	July	Aug.	Sept.
1931	72.9	76.1	72.0	65.5
1932	67.2	74.4	73.1	62.0
1933	73.6	76.7	69.5	64.4
1934	68.2	76.1	72.7	55.9
1935	65.3	75.8	78.6	61.6
1936	72.0	80.9	74.4	63.9
1937	66.1	75.7	76.7	64.2
1938	68.8	74.4	75.1	65.4

Data from monthly reports of U.S.D.A. weather bureau.

years. Shortage of irrigation water was responsible for low yields in 1934 and 1936. The very high temperatures in July, 1936, were also very detrimental. Both psyllids and early blight were responsible for the low yields of 1938. Prior to 1937, all the seed lots used were grown in the dry-land plots at Alliance.[3] The seed for 1937 and 1938 tests was produced in isolated rogued plots on the Scottsbluff farm.

In six of the seven years at Scottsbluff, the later strains outyielded the early ones as shown in table 2.

The yield of U. S. No. 1 grade tubers was rather consistently greater with the later strains but the quality of the tubers was not always so good, because of "feathering" resulting from immaturity at harvest. Strains did not vary consistently as to percentage of first-grade tubers. Most first-grade-size tubers were produced with the later plantings. The percentage of No. 1 size varied less from year to year than on dry land (3).

The percentage of rough potatoes varied a great deal, but throughout the period it averaged much the same for all strains. The later strain tubers appeared not to have so good type as the others, chiefly because they were larger. With later plantings of late strains this larger size resulted in longer potatoes, whereas with early plantings, many tubers were more elongated or bottle-necked than with early strains.

Scab was serious only in two years. In 1931 when scab was very prevalent, it was highest in the earlier strains, being a principal cause for the low percentage of U. S. No. 1 tubers in the early strains that year.

[3]H. O. Werner. Performance of clonal strains of Triumph potatoes. I. Test of Triumph strains on dry land in western Nebraska. Am. Potato Jour. 17: 66-80.

TABLE 2.—*Test of five strains of Triumph potatoes and five other varieties during several years at Scottsbluff with irrigation.*

Triumph Strain or Variety	1931			1933	1934	1935		1936				1937			1938			
	Planting Date																	
	June 10	June 10	June 30	June 15	June 15	June 8	June 25	May 15	June 10	June 25	July 12	May 28	June 15	June 25	May 25	June 15	June 8	June 25
	Harvesting Date																	
	Sept. 17	Oct. 9	Oct. 9	Oct. 6	Sept. 28	Oct. 9	Oct. 9	Sept. 29	Sept. 29	Sept. 29	Sept. 29	Oct. 5	Oct. 5	Oct. 5	Sept. 15	Oct. 5	Oct. 1	Oct. 1
Number of Plats and Plants per Plat (Number of rows per plat in parenthesis when more than single row)	12-50			4(5)66	3(3)66	10-36	5-36	9-45	5-45	5-45	5-45	10-41	10-41	10-41	10-25	10-25	10-25	10-25
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)		
Total Yield—Bushels per Acre																		
Very Early	341	501	464	416		470	399	102	199	91	115	222	348	328	127	137	184	175
Early	361	478	445	384	142	450	458	107	269	134		277	479	357	186	160	197	185
Medium	340	476	462	460	157	491	368	125	248	146			449	382				
Late	301	462	478		142	492	457											
Very Late	277	412	443		140	518	459		260				477					
Irish Cobbler						289	420	144	200	109		314	415	397	273	205	227	215
Warba						374	394	150		120	104	286	397	387	210	179		
Chippewa						354	333		201			328	465		162	134	200	196
Katahdin						269	225		232				351				176	
Russet Rural						277	258		169									
S. Dif.	14.2**	23.7**	14.9			13.4**						61*	54**	32**	36**	31**	26**	38**
U. S. No. 1 Grade—Bushels per Acre																		
Very Early	299	244	290	366		372	314	63	153	70	75	201	303	304	83	84		
Early	228	264	331	352	103	351	371	64	200	101		251	347	327	137	102	129	130
Medium	214	242	327		115	352	316	82	185	102			344	356			143	149
Late	175	251	364		83	384	377											
Very Late	178	132	367		101	414	389		193				370					
Irish Cobbler						194	315	85	148	114		279	324	355	188	73	156	173
Warba						123	384	90				218	200	352	128	89		
Chippewa						326	296		139		64	282	408		107	78	142	162
Katahdin						231	171						308				136	
Russet Rural						213	237		125									

*F values exceed 5 per cent level, **F exceed 1 per cent level.

TABLE 2 (Continued).—*Test of five strains of Triumph potatoes and five other varieties during several years of Scottsbluff with irrigation.*

Triumph Strain or Variety	1931			1933	1934	1935		1936				1937			1938			
	Planting Date																	
	June 10	June 10	June 30	June 15	June 15	June 8	June 25	May 15	June 10	June 25	July 12	May 28	June 15	June 25	May 25	June 15	June 8	June 25
	Harvesting Date																	
	Sept. 17	Oct. 9	Oct. 9	Oct. 6	Sept. 28	Oct. 9	Oct. 9	Sept. 29	Sept. 29	Sept. 29	Sept. 29	Oct. 5	Oct. 5	Oct. 5	Sept. 15	Oct. 5	Oct. 1	Oct. 1
Number of Plats and Plants per Plat (Number of rows per plat in parenthesis when more than single row)	12-50			4(5)66	3(3)66	10-36	5-36	9-45	5-45	5-45	5-45	10-41	10-41	10-41	10-25	10-25	10-25	10-25
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)		
Percentage U. S. No. 1 Grade																		
Very Early	57.2	48.7	62.5	87.9		79.2	78.6	62	77	77	61	90	87	93	65	62		
Early	63.1	55.3	74.4	91.6	72.6	78.0	81.0	60	74	76		91	72	92	74	64	70	74
Medium	63.0	50.9	70.9	91.7	73.0	71.6	85.8	66	75	70			77	93			**73**	81
Late	58.0	54.4	76.2		58.3	78.0	82.6											
Very Late	64.4	32.0	82.8		72.4	80.0	84.8		74				78					
Irish Cobbler						67	75	59	74	67		89	78	89	69	36	69	81
Warba						45	72	61		73	66	76	50	91	61	49		
Chippewa						92	89		69			86	88		66	58	71	83
Katahdin						86	76		70				68				77	
Rus. Rural						77	92		74									
Percentage Rough Potatoes																		
Very Early	6.4	2.3	1.5	3.1		12.6	6.4	7.1	1.8	3.5	3.0	4.7	5.3	0.7	3.7	2.7		
Early	6.6	2.7	3.0	1.6		11.3	4.8	4.8	4.1	1.1		15.3	17.9	1.5	2.3	4.3	7.4	3.0
Medium	4.2	1.2	1.2	3.8		12.3	2.1	2.9	1.7	2.8			12.7	1.1			5.1	1.2
Late	10.9	3.5	3.5			8.5	5.4										**7.7**	
Very Late	10.5	3.4				9.8	3.2		4.7				13.3					
Irish Cobbler						8.3	7.8	3.3	3.7	5.8		14.2	6.5	7.7	3.3	8.2	1.4	5.5
Warba						20.9	12.2	5.8	1.8	7.0	1.2	38.5	27.6	3.2	15.2	17.9		
Chippewa						1.0			1.0			5.5	2.5		1.2	3.0	5.2	0.5
Katahdin						0.5	1.9		2.7				1.8					
Rus. Rural						3.7	0.2		2.0									

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Harvest cracking differences were mostly caused by season and time of planting or harvesting. The later strains cracked a trifle more than the early ones.

There was no difference between strains in percentage of potatoes cut at digging time.

The later strains seemed to have slightly lower percentages of No. 2 size tubers than the earlier ones. The No. 3 size constituted a very small part of any crop. When it amounted to more than 3 per cent of the crop, the early strains again had higher percentages than did the later ones.

Every season the vines of the late strains were still very green at harvest time and only those from early plantings were more than two-thirds mature. The vines from early strains were practically dead each year except from the latest plantings. With late June planting, vines of very early strains were more mature by early October than were those of the latest strain in the early plantings. In early blight years, as 1938, plants of the early strains were damaged most severely.

When all aspects are considered the data show little difference between strains during these years. The limiting factors against late strains are: excessively green vines at harvest time and somewhat longer and slightly larger and rougher tubers. The worst factors against early strains are: severe early blight damage possibly indicating greater early blight susceptibility and low yields because of small plant size. As this latter shortcoming can be avoided by planting seed pieces closer in the row, it seems that the earlier strains offer the greatest promise and that strains later than midseason have not shown up with any special merit.

Among the other varieties tested in comparison with these strains, the Warba was less productive than the earlier strains of Triumphs. With all except very late plantings, it produced a very high percentage of very rough poor type and often very many sunburned or scabby tubers. It is useful for producing very early potatoes and should be harvested when ripe.

The Irish Cobbler did not yield so much early in the season as did the Warba and the early Triumph strains. It outyielded them in total production only a few times. The tubers were often rough and very scabby and consequently not especially desirable. The absence of harvest cracks is a great advantage to the Irish Cobbler.

The Chippewa produced a high yield of good tubers that were invariably smooth. This variety may have some merit in the irrigated districts as a late variety to be planted earlier than midseason Triumphs.

SECTIONAL NOTES

CALIFORNIA

The actual acreage of potatoes as reported by the County Commissioner for Kern county this season is as follows: Edison, 9939; Wasco, 3434; Shafter, 4643; Lerdo, 7922; Saco and Rosedale, 938; Jasmine and McFarland, 373. Including the 12th of April the shipments from Edison/Arvin totaled 615 cars whereas until this time last year, no cars were shipped, nor were any shipments made before this date in 1938.

The market in the Edison District started out as high as $2.50/2.75 and by the 12th of April had gone down to $1.40/1.50 on 100 lb. sacks and $1.45/1.60 on 50 lb. sacks U. S. No. 1; U. S. No. 1 Size B .80/.90 on 100 lb. sacks and .90/1.00 on 50 lb. sacks; No. 2's .70/.90 in 100 lb. sacks—ungraded egg-size .40/45 *per cwt.*—small egg-size .25/.30 *per cwt.*

After receiving the report concerning the damage and delay in Alabama and the South Atlantic States, the growers steadied their prices since they naturally figured on the increased outlet for their potatoes.

The shipments from the District are estimated between 125-150 cars daily for this week and will be increasing gradually, with the peak probably being reached between the 15th-30th of May. (Apr. 15).—E. MARX.

FLORIDA

Temperatures ranging from 20° to 26° F. caused damage to some seed in the potato fields at Hastings, Florida during January. Since the weather continued cold throughout February, the growth of the crop was delayed. Favorable growing conditions did not exist until March. However, the crop looks especially good at present (April 3), and most of the acreage should produce a normal, if not better than a normal, yield. The greatest handicap is the lateness of the crop. Harvesting will not start until the 15th of April whereas, in most seasons, harvesting generally starts the last week in March, and the peak is reached by the middle of April.

No late blight has appeared in the area to date. Some leaf roll is evident in fields planted with the Katahdin variety, and some mosaic is present in the fields where Spaulding Rose has been planted. Ring rot is beginning to appear in some of the fields planted with infected seed stocks. Only a small percentage of the acreage was planted with

seed containing a trace of ring rot; therefore, this disease should cause little trouble at Hastings this season.

The acreages of the different varieties planted in the Hastings Section in 1939 and 1940 are shown in the accompanying table.

*Acreages of the different varieties of potatoes planted in the Hastings Section, Florida, in 1939 and 1940**

Variety	1939 Acres	1939 Per Cent	1940 Acres	1940 Per Cent
Katahdin	7,047	51.4	9,469	78.9
Spaulding Rose	5,306	38.7	1,226	10.2
Earlaine	334	2.4	763	6.4
Bliss	275	2.0	375	3.1
Miscellaneous	745**	5.5	167***	1.4
Total	13,707	100.0	12,000	100.0

*Based upon data obtained from the Bureau of Agricultural Economics, U.S.D.A., Orlando, Florida.
**Includes 695 acres of White Rose.
***Includes 50 acres of Sebago.

(Apr. 3).—A. H. Eddins.

MAINE

It seems probable that Maine will be shipping 38,000 cars, or thereabouts, for the season, which is contrary to some of the more optimistic prophets earlier.

We have had one of the most orderly markets ever enjoyed. The prices remained fairly stable all winter with some changes up and down, the fluctuations, however, moving within a short range. On the whole, it has not been a profitable deal for the Maine grower because of the smaller yield and heavier shrinkage. Although the shrinkage has been heavy on the basis of U. S. No. 1 or better grades, nevertheless all grades have been going to market which many feel has had a very depressing influence on the returns for the better grades. Whether growers are still getting more for their total crop than would be true if the poorer grades were kept at home is, of course, a debatable question but it seems decidedly doubtful.

There is considerable dissatisfaction with the true Branding Law and the Advertising Tax. If it were now to be decided by the growers

there seems little doubt that both laws would be repealed. There is a good possibility, however, that by diverting more of the funds to research that the advertising law may be saved. Until growers in other states are ready to have a National Branding Law it is doubtful if Maine growers will be content to continue that existing legislation.

Even though the Crop Reporting Service estimate indicates a five per cent increase in acreage for Maine, the figures from the growers intentions to plant, obtained from all growers in Aroostook, haven't borne out this estimate. There is an indication of a slight increase but not so marked as the government releases indicate.

Very little preparation has been made for the coming season's operations. Most of the fertilizer was purchased last fall but very little has been taken home by farmers.

A very marked increase in the acreage of Katahdins and Chippewas is in prospect for the coming season. For three years we have had very unfavorable conditions for the Green Mountain variety and our growers are avoiding the planting of this variety. (Apr. 13).—FRANK W. HUSSEY.

NEBRASKA

It is rather early to give very good information on the contemplated acreage for the late main crop in Nebraska. The early crop now being planted in central Nebraska consists largely of Irish Cobbler, with a small amount of some of the new varieties, such as Chippewa and Warba. A small portion of that acreage is also being planted to very early-maturing Bliss Triumph strains. Because of the fact that the Bliss Triumph variety is more subject to injury in the hot part of the season, it is successful only about one season out of three when it is planted. In years when the summer temperatures are lower, and the Bliss Triumph is successful, the prices obtained are very satisfactory.

Crop conditions, as a whole, through western Nebraska, where the late main crop is planted, are reasonably good. There has been an insufficient amount of winter moisture, and growers on dry land have been quite pessimistic until lately. During the last few days, there was approximately an inch of precipitation in the form of rain or snow. It has improved conditions somewhat, but unless considerably more falls between now and the first of June, growing conditions will be hazardous. Dry land growers consider that there should be at least 30 inches of moist soil, to give a fair assurance of a crop, whereas much of our dry land areas have 12 to 18 inches at the present time.

Where river irrigation is practiced, growers are also pessimistic, because the report is that there is much less storage water in mountain reservoirs than for several seasons past. This situation could be improved, if rain should come between now and planting time.

For several weeks past, growers have been purchasing their seed needs, both Certified and commercial potatoes, and such stock is scarce at the present time. All shipments of certified potatoes have been completed for two or three weeks, and carlot movement is practically over. Indications are that there will be a slight increase on the planting of potatoes, both certified and commercial. However, a larger increase is expected in the certified than in the commercial plantings.

The Certified Potato Growers, at their annual meetings, about the middle of March, decided to send a number of representatives on a Good Will Tour through southern states. Eight growers were selected to make this trip, and departed from western Nebraska on the 12th of April. Their first destination will be Alexandria, Louisiana, where they plan to join the Louisiana Potato Tour, going through the central and southern parts of the state. From Louisiana, they will go through Mississippi and join the Potato Tour in Alabama, returning from there about the 23d of April. This will be the second season that the Nebraska growers have followed this practice, and is a response to trips made by southern growers into Nebraska for several seasons past. (Apr. 15).—MARX KOEHNKE.

NORTH CAROLINA

North Carolina farmers report their intentions to plant one per cent more Irish potatoes than were planted last season. Although it is indicated that the commercial early crop will be decreased from last year at least 5 per cent, the non-commercial farm, early and late crops are expected to be increased to the extent of offsetting the smaller commercial crop. This one per cent increase will result in 83,000 acres being planted as compared with 82,000 last year and 79,000 acres for the 1929-'38 average.

The month of February was very wet in Eastern North Carolina and much of the crop was planted late. However, I do not believe that will make much difference in the maturity of the crop, since we have had good weather during March and April. A larger percentage of our crop has been planted this year with side placement fertilizer machinery. (Apr. 16).—ROBERT SCHMIDT.

SOUTH CAROLINA

The potato crop in South Carolina is a little later than usual as a result of the very unfavorable weather that prevailed early in the season. Cold weather delayed sprouting of the tubers and checked the growth of the young plants after they had emerged. The stands seem to be very good in most sections, however, and growing conditions have been favorable for the past ten days.

The total acreage for the state is estimated at 14,000, a slight increase above the 1939 acreage. The bulk of the crop is Irish Cobbler although small lots of Bliss Triumph, White Rose, Green Mountain and Katahdin are reported to have been planted.

A meeting of potato growers was held in March for the purpose of discussing better methods of handling the potato crop so that the tubers will reach their destinations in the best possible condition. The growers were especially interested in a presentation of improved methods of digging and packing the crop and in a discussion of the methods now being employed for washing potatoes before they are packed for shipment.

This season all the seed potatoes intended for planting in Charleston County were inspected for mechanical injuries, soft and dry rots, freezing injury, scab, rhizoctonia, etc. upon their arrival. It was reported that most of the potatoes inspected were in very good condition and fairly free from observable diseases. This inspection is the first step in a plan to check planting stock used in this state so that growers may be assured of getting the best seed potatoes available, and it is probable that the inspection will be extended to include careful observations of fields of seed potatoes in the states where they are produced. (Apr. 11). —MITCHELL JENKINS, JR.

TEXAS

At the present time the crop is progressing nicely. Some early potatoes in the Rio Grande Valley have been harvested and the Eagle Lake—Sugarland—Wharton section has a nice prospective crop, but the acreage is below average. Frost throughout the state last Friday night may have some retarding effects on the crops in this area and in the East Texas section. I do not think, however, that the temperatures were low enough to have damaged the crop very seriously. (Apr. 15).—J. F. ROSBOROUGH.

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THE RESPONSE OF POTATOES TO DIFFERENT SOURCES OF NITROGEN, PHOSPHORUS AND POTASH[1]

T. R. COX AND T. E. ODLAND

Rhode Island Agricultural Experiment Station, Kingston, R. I.

Many experiments designed to evaluate different materials used as sources of nitrogen, phosphorus, and potassium have been conducted with field crops at the Rhode Island Agricultural Experiment Station. It is the purpose of this paper to report briefly some of the more recent results of the experiments in which potatoes have been included.

The literature on the subject is extensive and there is frequent disagreement among the reports of workers regarding the most acceptable materials to use as carriers of the fertilizer elements. In order to understand the reasons for this lack of agreement it is necessary to consider soil conditions, weather conditions, and other factors which have operated during the growing season to influence the effectiveness of the material. Whereas nitrate of soda may prove superior to sulfate of ammonia during certain seasons or for certain crops, or *vice versa,* it cannot be concluded if either material is the more effective under all conditions. A critical attitude should likewise be directed towards any experimental results used as a basis for recommentions on phosphatic and potash fertilizers.

NITROGEN EXPERIMENT

Nitrate of soda and sulfate of ammonia have been compared at different soil pH levels on four of the permanent plats since 1893. Other carriers of nitrogen have not been tested with potatoes to any extent at

[1]Contribution No. 568 of the station.

this station and the results with only the two above named nitrogenous materials will be given in this paper. Lime has been applied to two of the plats in the course of the experiment so that a soil reaction of approximately pH 6.0 has been maintained. The remaining two are kept at a pH of about 5.0. Sulfate of ammonia has been applied as the exclusive source of nitrogen on one of the limed plats and on one of the plats receiving little lime, whereas nitrate of soda has been used on the two comparable plats. No lime has been applied to the more acid nitrate of soda plat. The yields are reported in table 1, based on entire plats in 1934 and on the average of plantings at four different dates on 1/40 acre areas for 1939.

TABLE 1—*Yields of potatoes with sulfate of ammonia and nitrate of soda*

Treatment	Nitrogen Carrier	Approx. Soil pH	Yields in Bushels per Acre					
			1934		1939		2-year Average	
			Total	Per Cent U. S. No. 1	Total	Per Cent U. S. No. 1	Total	Per Cent U.S. No.1
Little lime; standard potato fertilizer	Sulfate	4.7	305	93	273	88	289	90
	Nitrate	5.3	295	94	317	88	306	91
Well limed; standard potato fertilizer	Sulfate	6.0	333	94	331	93	332	93
	Nitrate	6.0	264	94	308	92	286	93

On the more acid plats in 1934 there is a slight, but hardly significant, advantage in favor of the sulfate. Comparing the well-limed plats in 1934, yields on the sulfate plat exceeded those on the nitrate plats by 69 bushels an acre. In 1939 the well-limed sulfate plat outyielded the nitrate plat by 23 bushels per acre, whereas the yield after nitrate was considerably better on the more acid plats. There was a slightly larger per cent of marketable U. S. No. 1 tubers on the limed plats in 1939.

A probable explanation for the reverse order of yields on the acid plats for 1934 and 1939 may be derived by comparing seasonal rainfall data. Rainfall for May 1934 was slightly greater than normal for the month whereas for May 1939 it was only .67 inches or about 18 per cent of normal. In view of the rapid leaching of nitrate of soda under

heavy rainfall, it is reasonable to assume that much of the nitrogen supply was lost to the potato crop before it could be utilized. Results reported by Brown, Owen, and Tobey (3) indicate that nitrate of soda is not satisfactory as the sole source of nitrogen in seasons of heavy rainfall, and that ammonium sulfate is highly unavailable during periods of drought, especially on acid soils. The 1939 season at Kingston was very dry until the latter part of August. Carolus (4) by experiments in Virginia, has demonstrated that 24 per cent of the nitrogen uptake of a potato crop is absorbed during the tenth week, and 32 per cent during the twelfth week of the growing season. Both of these periods occurred during the most severe part of the drought of 1939.

Relative yields on the limed plats show a superiority of sulfate for both years under the conditions. The yield difference in favor of the sulfate is greater in 1934, when rainfall was somewhat more ample than in 1939. It is generally accepted that the more slowly available ammonium sulfate will last longer during a wet season than will nitrate of soda.

Phosphate Experiment

In table 2 are presented the results for a three-year period on the old phosphate experiment that was originally set up in 1894. Phosphorus has been supplied continuously in one of the five forms indicated. Various field crops have been grown in the course of the experiment. Applications of fertilizer have been calculated to supply equal amounts

Table 2—*Yields of potatoes with different phosphorous sources*

Phosphorus Carriers	Average Yields in Bushels per Acre							
	1931		1932		1933		3-Year Ave.	
	Limed	Little Lime	Limed	Little Lime	Limed	Little Lime	Limed	Little Lime
Superphosphate	303	310	258	197	228	133	263	213
Superphosphate ½ P	235	263	199	141	136	113	190	172
Triple Superphosphate	329	262	285	271	234	207	283	247
Rock Phosphate 1-½ P	298	342	218	238	115	89	210	223
Rock Phosphate	301	311	197	206	111	76	203	198
Ground bone	314	378	257	299	204	160	259	278
Basic slag	375	343	266	244	190	147	277	245

of phosphoric acid each year except on areas receiving superphosphate at only 50 per cent of the normal rate and another duplicated area receiving rock phosphate at 150 per cent of the normal rate. The standard or normal rate of application of phosphorus in 1931 and 1932 was 50 pounds of phosphoric acid per acre, equivalent to 250 pounds of 20 per cent material. In 1933 it was 80 pounds of phosphoric acid per acre, supplemented each year by adequate applications of nitrogen and potash.

As shown in table 2, all the phosphorus carriers involved in the experiment have been compared under two different rates of lime application. On one set of plats, lime was applied in amounts adequate to maintain the soil reaction at pH 6.0 or above, whereas the other plats receiving lesser applications of lime had a soil reaction of pH 5.0 or slightly greater.

The growing season for 1931 was considerably more favorable for potatoes than the 1932 and 1933 seasons. The effects of dry weather are rather strongly reflected in the yields for the two latter years, especially in 1933, when some very low yields were recorded. The lowest yields were produced on the rock phosphate plats, with decided decreases after the other materials also. Although factors other than the subnormal conditions may account for some of the decreases in yield, the sub-normal rainfall for May, June, and July was no doubt chiefly responsible.

The results for each year that potatoes have been grown in the experiment indicate that triple superphosphate containing 45 per cent P_2O_5 has been a very satisfactory source of phosphorus on both the limed and the more acid plats. All yields have consistently exceeded those on plats receiving regular superphosphate. Except for the 1931 season, the increased yield for triple superphosphate over the regular grade was greater on the more acid plats. Relative potato yields for the two superphosphates as reported by Hartwell and Damon (6) for 1922 and 1923 are very similar to the yields for the more recent three years of the experiment.

Basic slag has compared favorably with superphosphate for all years when potatoes have been included in the experiment. Based on the three-year averages, the yield after basic slag on well-limed plats was 105 per cent of the superphosphate yield, and on the more acid plats, 115 per cent of the superphosphate yield. For the ten years reported by Hartwell and Damon (6) the yields were not significantly different in either case. It appears that some benefit on the less-limed plats can be attributed to the basic effect of the slag which carries a considerable content of lime.

Yields with ground bone on the well-limed plats have averaged about the same as yields with superphosphate when supplied on an equal P_2O_5 basis.It may be noted from the table that yields after superphosphate applied at half the standard rate are considerably lower than on the plats receiving the standard amount. On the well-limed plats the yields were only 72 per cent as great for the low rate of application, indicating that the level of phosphorus fertility for the group of plats was probably low enough to cause measurable differences in response to phosphorus, depending on the relative availability of the different carriers.

The effect of different soil reactions on the availability of the phosphorus of the different materials is very well indicated by the yield data of table 2. Except for the very dry season of 1933, the yields after rock phosphate and ground bone were greater on the acid plats. Most of the phosphorus in either of these materials is in the form of tri-calcium phosphate which is less available to crops than that of the superphosphates. This relative unavailability is reflected by the yields on the well-limed plats, which are considerably lower after rock phosphate than after the other materials. On the other hand, all yields are considerably lower on the more acid plats receiving triple superphosphate, regular superphosphate, and basic slag, than on the well-limed series. The three-year average for superphosphate is 263 and 213 bushels per acre respectively, for the limed and the little-limed plats. In the same order, yields are 283 and 243 bushels per acre for the triple superphosphate, and 277 and 245 bushels for basic slag. Although rock phosphate and ground bone yielded only 77 and 98 per cent as much respectively as did the superphosphate on the well-limed series, their respective yields are 93 and 131 per cent of superphosphate yields on the more acid series.

Potash Experiment

The original potash experiment, begun at the Rhode Island Agricultural Experiment Station in 1911, provided for a comparison of four different potash carriers: kainit, muriate of potash, sulfate of potash, and sulfate of potash-magnesia. As shown in table 3 it also included a plat (No. 116) which has received very low applications of potash in the form of sulfate for the period reported in this paper. This has usually been about half the amount applied as the standard rate to the other plats. For the first sixteen years of the experiment no application of potash was made to this plat. Before the end of this period, 1926,

TABLE 3—*Yields of potatoes with four different sources of potash.* (*Bushels per acre*)

Variety	Year	Plat Number and Treatment					
		114 Kainit	115 Muriate Potash	116 Low K (Sulfate)	117 Sulfate Potash	118 Sulfate Pot. Mag.	119 High K (Sulfate)
Rural Russet	1926	180	104	73	208	193	347
Green Mountain	1927	194	165	81	185	143	334
Green Mountain	1930	323	383	236	393	302	461
Green Mountain	1931	340	323	196	366	336	404
Green Mountain	1934	142	209	161	238	219	280
Average		236	255	149	278	239	367

yields of the various crops were so highly abnormal that small applications of potash were begun. Another plat also included in the experiment (No. 119) has received twice the standard amount of potash in the form of sulfate. It is the only plat reported in table 3 that has received what may be considered adequate applications of potash.

As the data in table 3 indicate, the standard rate of application of potash has been a sub-optimum amount. The level of potash fertility has therefore been low enough to provide excellent conditions for comparing the relative value of the different materials for the potato crops. Applications of nitrogen and phosphorus to the different plats have been the same each year. No manure has been applied to any of the plats during the course of the experiment. Lime applications have maintained the soil reaction within a range of approximately pH 5.5 to 6.0.

A comparison of the four potash carriers for five different seasons is presented in table 3. The Green Mountain variety has been grown each year except in 1926 when the Rural Russet variety was used.

In 1926 the differences in yield on the four plats receiving potash at the standard rate from the four different sources are not very great and indicate little advantage of one carrier over another. It is interesting to compare the extremely low yield of 73 bushels per acre for plat 116 with the yields on plats that have received a standard rate over the previous 16 years of the experiment. It may also be pointed out that plat 119, the optimum fertilizer plat, produced a yield of 347 bushels per acre, compared with 208 bushels for plat 117 which received the same potash material, but at a lower rate.

In 1927 the kainit plat yielded 29 bushels an acre more than did the plat receiving the same amount of potash in muriate. The sulfate plat yielded 20 bushels more than the muriate. Even with a small application of potash this season on plat 116, the crop was very stunted and yielded only 81 bushels per acre.

The 1930 season was very favorable for potatoes and yields were practically twice as great on some of the plats as in the previous two years. Results again indicate that the comparison of the four materials is on a potash deficiency basis, in view of an increase of 68 bushels per acre of plat 119 compared with plat 117. The yield on the high potash plat 119 that received sulfate at the rate of 200 pounds per acre of K_2O this year was practically twice as large as the yield on the low potash plat 116 that received 40 pounds per acre of K_2O in sulfate. The yield of 393 bushels per acre on plat 117 that received the standard application of 100 pounds per acre of K_2O in sulfate for this year is 66 per cent larger than that on the low potash plat. Yields that followed kainit and sulfate of potash-magnesia were considerably lower than those following muriate or sulfate.

The next year, 1931, was also a favorable potato season and the yields were very satisfactory. The yield following muriate dropped somewhat lower in relation to kainit and sulfate of potash-magnesia than it has averaged for the five-year period. Again there was a marked increase in yield with the extra potash on plat 119.

The lower yields for 1934 reflect the effects of a very dry season. Relative yields are in the same order as averages for the five years. The optimum treatment plat had relatively less advantage this year since the low moisture was the limiting factor rather than the nutrients supplied.

The average for the five crops of potatoes range from 149 bushels per acre on the low potash plat, 116, to 367 bushels on the optimum treatment plat, 119. Considering response to the different carriers applied at the same rates, the kainit and potash-magnesia plats averaged practically the same, and about 20 bushels less per acre than the muriate plat. The sulfate of potash plat averaged about 20 bushels more per acre than the muriate plat. Besides comparing the four different sources of potash, results in table 3 indicate the importance of applying an adequate amount of potash if high yields are to be obtained.

Table 4 presents a two-year comparison of muriate and sulfate of potash applied at the different rates indicated in column 2. The low grade carriers, kainit and potassium-magnesium sulfate, were discontinued after 1934 as they are not now considered as economic sources of potash.

TABLE 4—*Yields of potatoes with different levels of muriate and sulfate of potash*

Material	Rate Lbs. K_2O per Acre	Yields in Bushels per Acre					
		1935		1939		2-Year Average	
		Total	Per Cent U. S. No. 1	Total	Per Cent U. S. No. 1	Total	Per Cent U. S. No. 1
Muriate	100	239	88	264	94	251	91
Sulfate	50	195	76	226	88	210	82
Sulfate	100	246	87	277	92	261	89
Muriate	200	237	88	312	95	274	91
Sulfate	200	302	90	341	95	316	92

Although differences between muriate and sulfate as potash sources for potatoes have not been great, there appears to be a slight advantage in favor of the sulfate, especially at the high rates of application. At the present time the cost of potash in the sulfate form is about one-third more per pound than in the muriate. The differences in yield have not justified this extra cost for the sulfate carrier of potash. The foliage was observed to be of a darker green color after the sulfate and the vines usually stood up for approximately a week longer than on the muriate plats. Berkner and Schlimm (2) attribute the pale color of the foliage in muriated plots to the effects of chlorine. It may also be observed from the table that considerably better yields resulted when potash was applied at the highest rate of 200 pounds per acre. There was also a higher percentage of U. S. No. 1 potatoes with an adequate application of potash.

SUMMARY

Yields of potatoes for 1934 and 1939 are compared for permanent plats which have received nitrogen for a period of more than 40 years from one source, either nitrate of soda or sulfate of ammonia. The two materials are compared on plats receiving little lime where the soil reaction is about pH 5, and on plats well limed where the soil pH is 6 or above.

The yields were considerably better after sulfate of ammonia on the well-limed plats, especially in 1934 when the rainfall was great enough to cause some leaching of nitrate of soda early in the season. There

were only small differences in yields between sulfate and nitrate on the acid plats.

With sulfate of ammonia there were marked increases in yield by the use of lime, whereas the yields after nitrate were as great if not somewhat greater on the unlimed plat.

Relative yields of potatoes for 1931, 1932, and 1933 on the old phosphate experiment are reported, comparing results with five different carriers of phosphorus. Compared on the basis of equal rates of P_2O_5, the five materials may be ranked as follows, in order of yields obtained—triple superphosphate, basic slag, superphosphate, ground bone, and rock phosphate. Yields were significantly lower on plats receiving one-half the normal application of P_2O_5 in superphosphate. Increasing the application of rock phosphate by one-half produced an average increase in yield of 12.7 per cent on plats receiving limited applications of lime, but no consistent increase on well-limed plats.

Four potash carriers, muriate of potash, sulfate of potash, kainit, and potassium-magnesium sulfate were compared as sources of potash for potatoes in a report of results covering five years. The best results were obtained with sulfate of potash and the poorest with kainit. Muriate and sulfate at different rates of application are compared for a two-year period. The results indicate a slight advantage for the sulfate, especially at the high rate of application. However, the most economical source of potash at present is high grade muriate, in view of the small differences noted in results throughout this experiment.

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REPORT OF THE COMMITTEE ON STANDARDIZATION OF FIELD PLOT TECHNIQUE

One of the more recent developments in the science of statistical analysis has been the transformation of data to some function of those data other than the one used for the original observations. In those experiments where the data conform to a Poisson or a binomial distribution or where the several variables have different variances the direct application of the analysis of variance is a questionable procedure. The generalized error calculated from such experiments is said to be invalid. It is the purpose of your committee on the standardization of field plot technique to review a few of the papers dealing with this problem and to comment upon them.

COCHRAN, W. G. 1938. Some difficulties in the statistical analysis of replicated experiments. Emp. Jour. Agr. 6:157-175.

In this paper the author discusses these three methods of transformation; the square-root, the inverse sine, and the logarithm transformation. The purpose of the transformations is to permit the calculation of a generalized error from those data which treated in their normal form would produce an invalid generalized error. As Cochran expresses it, "——— the most important condition for the application of a combined analysis of variance: *the treatment comparisons must be such that they may be reasonably expected to have the same variance.* When this is not so, the error found by the analysis is a weighted mean of a number of different errors and is not really applicable to any of the treatment comparisons."

The author's summary is a good review of the paper so it is stated here *verbatim.*

The analysis of variance is now widely applied in interpreting the results of replicated experiments. Some times, however, a combined analysis on the original data has little meaning and gives misleading results, because the treatments have different variances. A numerical example is given to illustrate such a case.

These cases may be divided into two groups. (1) With yield-data, or whole-number counts of over 100 per plot, they occur very rarely, but may do so if some treatment differences are of the order of several hundred per cent, or if there is a partial failure of certain treatments or plots. The analysis is best carried out by omitting some treat-

ments or plots. (2) With small whole numbers or percentages, the distributions tend to follow the Poisson and binomial types, respectively, and there is a known relation between the variance and the mean. Data of this type should be transformed before an analysis to a scale on which the variances are equal.

Three transformations have proved particularly useful in practice. (a) The square root, for whole numbers per plot between 10 and 100. If the majority of the plot-yields are under 10, one-half should be added to each plot-yield before taking the square root. (b) The inverse sine, *i.e.*, the angle whose sine is the square root of the fraction, for percentages and fractions based on the ratio of small numbers. Percentages can, however, often be dealt with either by square roots, for small percentages, or by a direct analysis, for percentages from 30 to 70. (c) The logarithm, for distributions in which the standard error is proportional to the mean.

Numerical examples are worked, illustrating the use of each of these transformations and the way in which to present the results of the experiment.

A brief discussion is given of the analysis when the results consist of the number of plants in each of a number of grades (*e.g.* healthy, slightly diseased, severely diseased).

With factorial experiments in which the main effects produce large differences, the experimenter must consider what is the most natural definition of the independence of two factors, since the conventional test of interactions in either the original or the transformed scale may have little relation to this. A numerical example is given illustrating this point.

Comment

The urgent necessity of some form of transformation for so many different types of experimental data serves to emphasize the weakness inherent in any generalized error no matter how it may have been derived, namely, that it must be assumed that the different treatments, varieties, years, locations or what not *have equal variances.* Such instances of course are rare rather than common, but what is worse there are so many cases of in-betweenness, the variances are neither definitely equal nor definitely unequal. The investigator must decide if the variances are sufficiently different that he should use some one of the three transformations so far proposed, and no doubt there will be others in the future, or apply the usual form of the analysis of variance.

If the investigator is to make the decision he will need a guide to aid him. There are several 'rule of thumb' devices given by Cochran in his summary. Read them over again and you will find that the investigator still has to exercise his own judgment. The final test that most of us will use will be the standard error of the experiment and the temptation will be to use the method which affords the smallest standard error. That, of course, is wrong, absolutely unsound statistical practice yet most of us will do it and then justify our decision by such an interpretation of the flexible 'rule of thumb' as may be necessary.

Recall in Cochran's summary—"The analysis is best carried out by omitting some treatments or plots." Always there is real danger in removing data that do not agree with the rest of the observations. The estimate of the degree of good or poor agreement so often may be based on the experimenter's preconceived notion of what the experiment should show and so is decidely biased. The arbitrary discarding of portions of the data because they fail to conform with the rest of the data may well lay the researcher open to criticism. It is much too easy to be misled by what one thought was his judgment but which proved to be his desire.

CLARK, Andrew and Warren H. Leonard. 1939. The analysis of variance with special reference to data expressed as percentages. Jour. Amer. Soc. Agron. 31:55-66.

In this paper the authors point out the need of transforming percentage data to some other function in order to construct an estimate of the generalized error. This applies particularly to those percentages derived from discrete data, such as germination percentages resulting when the number of seeds germinated is divided by the total number of seeds and disease percentages obtained by dividing the number of diseased plants by the total number of plants.

Percentages derived from continuous data may be used in their original form, for example, where each variant is divided by an arbitrary constant value and so becomes a percentage of some standard; or such percentage values as seed purity obtained by dividing weight of pure seed by total weight of seed; or protein content calculated by dividing weight of protein by total weight; or sugar content by dividing weight of sugar by total weight of root. The authors state that such percentages as have just been enumerated need not be transformed.

It is possible that different imposed treatment variants may affect the basic homogeneity of the data to such an extent as to invalidate

the error provided by the analysis of variance. It is suggested by Clark and Leonard that a test for homogeneity be made before applying the analysis of variance inasmuch as such analysis might afford an invalid estimate of error when data are heterogeneous.

Conclusion

1. Discrete data representing counts of a given type, condition, or attribute and based on a determinate number of trials should be subjected to the transformation $p = \mathrm{Sin}^2 \Theta$ where it is proposed to combine them in any way to construct a generalized standard error. Whether such data represent the actual counts or percentages derived from them does not alter the situation.

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6. It is also indicated through illustration that even though data in their entirety exhibit such heterogeneity as to make an analysis of variance invalid, it may be possible to eliminate the data under certain variants of a source of variation and still combine the majority of the data for the determination of a valid generalized standard error with but little loss of information and generality.

Comment

To many of us who are agronomists rather than mathematicians, it is not always clear as to what is meant by "valid" or "validity." The Statistical Dictionary of Terms and Symbols by Kurtz and Edgerton (1) defines validity as, " 1) The extent to which a test or other measuring device measures what it purports to measure; the extent to which the scores obtained from a test or measuring scale can be used for prediction; (2) the accuracy with which any statistic represents what it is intended to represent." In a letter to Mr. R. J. Borden (2) Student wrote, "All that these people mean by valid is that they are rigidly justified in using the various tables and that is an advantage which is not only not worth going far to get, but may often be dearly bought."

The data which the authors used to illustrate the method are taken from a bunt experiment by Salmon (3). In this experiment several varieties of wheat were exposed to many collections of bunt and the reaction of the variety to the bunt is expressed as percentage infection. The data are ideal as illustrative material for they are quite variable. One of the varieties, the hybrid #128 is quite consistent with very high percentages of bunt from all collections; another variety the

Hohenheimer is quite consistent in that there was practically no bunt; and one or two other varieties are extremely inconsistent in their reaction, varying from 1 per cent to 93 per cent bunt. Presumably since these are discrete data it would be invalid to construct a generalized error from these data until one had first removed the most heterogeneous data and secondly, only after transformation to the angle function of the percentage values.

In the paper by Clark and Leonard they make a statement on page 57 as follows, "However, when a p (percentage) value of 0 or 1 occurs repeatedly under a given treatment variant under replication, it might be well to withdraw that portion of the data from the statistical analysis." When the use of a method of statistical analysis requires that certain figures be discarded arbitrarily one might question the general applicability of that method. It is dangerous to have to decide which are the most variable even though one has a mathematically correct device whereby he may select this most variable portion of the data.

In any experiment, except that rare instance where no one observation is different from any other observation, always there must be some variability, some heterogeneity. In fact, it is one form of heterogeneity that permits us to determine that one variety is better than another or that one variety reacts to one form of disease and not another. It seems particularly unorthodox to me to remove any data because of their extreme variability. In every case it must be a matter of relative heterogeneity and who is to decide exactly where the line shall be drawn such that some data shall be discarded while other data are used. In many experiments the abnormal observations or extreme variables often are the most important in the entire experiment.

Reading this paper raised so many questions in my own mind that I thought it would be of interest to work the data over with and without transformation into angles, and with and without removing the most heterogeneous data. In table 1 there are some figures which represent the standard deviation of a single variable or single unit of measurement as calculated in several different ways. First, the standard deviations resulting from the analysis of variance applied to the original data expressed in percentage and then from the same data after transformation to angles. Then the data were analyzed first with all the observations and secondly when the most variable collections, as determined by Clark and Leonard, had been removed.

In addition to calculating the standard error for the experiment

TABLE I.—*The standard deviation and the coefficient of variability as calculated from various arrangements of the original data*

	ALL OBSERVATIONS			
	Simple Sources of Variance Removed		Simple Sources & 'variety x collection' Variance Removed	
	Standard Deviation	Coefficient Variability	Standard Deviation	Coefficient Variability
Original data in percentages	22.75 ± .836	71.9 ± 3.62	5.46 ± .274	17.3 ± .63
Transformed into angles	17.34 ± .637	59.6 ± 2.76	4.90 ± .246	16.8 ± .61
	MOST VARIABLE COLLECTIONS REMOVED			
	Simple Sources of Variance Removed		Simple Sources & 'variety x collection' Variance Removed	
	Standard Deviation	Coefficient Variability	Standard Deviation	Coefficient Variability
Original data in percentages	22.68 ± .880	73.3 ± 3.93	4.43 ± .234	14.3 ± .54
Transformed into angles	16.94 ± .657	60.2 ± 2.95	4.41 ± .233	15.7 ± .60

when just the simple sources of variance were removed another set of standard deviation values has been determined from the variance remaining after the important 'variety x collection' interaction variance had been removed. Although it may be possible to show mathematically that there is a significant difference between these two sets of standard deviations in table I, still the difference is very small and I do not think that one conveys a bit more information than the other.

Admitting that the generalized error may be more valid, what have we gained by transforming the percentages to angles and discarding the most heterogeneous data? Those varieties most susceptible are still the most susceptible; those varieties most resistant are still most resistant; and those varieties more or less indeterminate are still indeterminate. In this experiment the only effect on the varietal means of the transformation to angles was to change one variety from third to sixth place; a repetition of the experiment might easily produce even greater changes in ranking. The interpretation of the results of this experiment have to all intents and purposes not been changed at all by the transformation to angles or by the removal of the most heterogeneous data.

Review

BARTLETT, M. S. 1936. Square root transformations in analysis of variance. Jour. Roy. Stat. Soc. Suppl. 3, (1):68-78.

The square root type of transformation of variable data before submitting them to the analysis of variance is discussed in this paper. If the analysis of variance is to be used to reduce experimental data of the Poisson type or in certain instances where the data are extremely variable or heterogeneous the author suggests the advisability of using the square root transformation. The transformation would produce more nearly normal variates and so provide a more valid estimate of error. The $\sqrt{x}$ for those cases where the data are over 10 and the $\sqrt{x + 0.5}$ when the data are under 10 are the two transformations provided.

Summary

In spite of the wide range of applicability of the direct use of analysis of variance, data sometimes occur which are more validly analyzed on another scale. The frequent value of the square-root transformation for analyzing field variation of a Poisson type is noted, and this transformation considered in some detail. Examples are given of data for which it has been of use.

Some discussion is also added on more controlled variation of the binomial type, and the analysis of this kind of data considered in cases where the use of X^2 is not valid.

It should, of course, again be stressed that the most valid analysis of data where the variation is something of an unknown quantity cannot be decided *a priori* without careful consideration of the variation that has actually occurred. The theoretical results in this paper may, however, be of value in making us more familiar with transformations which we sometimes have to consider.

Comment

Just out of curiosity I analyzed the data used in this paper first in their original form and then using the $\sqrt{x + 0.5}$ transformation. To my surprise there was no change in the significance of differences between the two treatments for the several varieties. In this instance

the data are quite variable by virtue of the fact that for the first two varieties the entire plot was weighed and recorded whereas for the remaining six varieties a quadrat sample was measured.

A portion of the data in their original form is found in table 2 and the corresponding transformed data are presented in table 3.

TABLE 2.—*Control of cockchafer larvae (original data)*

	A		B		C		D		E	
	a	b	a	b	a	b	a	b	a	b
1	13	28	29	61	5	7	5	14	0	3
2	16	12	12	49	4	2	12	5	2	3
3	13	40	23	48	4	4	1	14	2	2
4	20	31	15	44	1	5	5	9	2	7
5	16	22	17	45	2	2	3	8	0	0

TABLE 3.—*Transformed to* $\sqrt{x + 0.5}$

	A		B		C		D		E	
	a	b	a	b	a	b	a	b	a	b
1	3.674	5.339	5.431	7.842	2.346	2.739	2.346	3.808	.707	1.871
2	4.062	3.536	3.536	7.036	2.122	1.583	3.536	2.346	1.582	1.871
3	3.674	6.364	4.848	6.964	2.122	2.122	1.225	3.808	1.582	1.581
4	4.528	5.612	3.937	6.671	1.225	2.346	2.346	3.082	1.582	2.739
5	4.062	4.743	4.183	6.745	1.583	1.583	1.871	2.916	.707	.707

In table 4 the difference between the two treatments together with their standard errors and 't' values are displayed. Again there is no change in interpretation of the results of the experiment. If the analysis of the data in its original form were to produce invalid errors certainly they should appear in these data, in which two sets of observations are of the order of six to eight times the magnitude of the remaining six sets. Yet in table 4 it should be plain that there is no difference between the 't' values whether they are derived from the original data or from the transformed data.

In all likelihood there may be instances when the experimental data should be transformed to some other function before calculating a generalized error. Even though there are mathematical devices provided, some one of which may indicate the need of transformation, still the researcher has to decide for himself whether he should use the transformation or not. Striving for the most valid result is desirable, yet

TABLE 4—*Differences between treatments with their standard errors and their respective 't' values*

	A		B		C		D	
	Difference	*t*	*Difference*	*t*	*Difference*	*t*	*Difference*	*t*
Transformed	1.12 ± .56	2.00	2.66 ± .67	3.96	.19 ± .251	.76	.93 ± .33	2.84
Original	11.00 ± .51	2.16	30.20 ±7.97	3.79	.80 ± .920	.88	4.80 ±1.80	2.67
	E		F		G		H	
	Difference	*t*	*Difference*	*t*	*Difference*	*t*	*Difference*	*t*
Transformed	.52 ± .18	2.90	1.00 ± .24	4.10	1.33 ± .218	6.10	1.33 ± .31	4.22
Original	1.80 ± .49	3.67	3.70 ±1.01	3.66	5.20 ± .890	5.84	7.00 ±1.69	4.14

there is considerably more in the complete interpretation of experimental data than a valid answer no matter how mathematically significant it may be. Statistics alone in any form do not help too much, always they should be tempered by personal knowledge and observation during the progress of the experiment.

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J. R. LIVERMORE, *Chairman.*

PERFORMANCE OF CLONAL STRAINS OF TRIUMPH POTATOES
III.
COMPARISON OF STRAINS IN CENTRAL NEBRASKA (AT NORTH PLATTE) WITH AND WITHOUT IRRIGATION

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Trials for central-Nebraska conditions under both dry land and irrigation conditions were conducted as the North Platte Substation, where the altitude is between 2,800 and 3,000 feet. Potatoes were planted in mid-April and harvested from the 31st of July to the 9th of October. The mean monthly temperature for April ranged from 47.1° to 52.6° F.; in June 68.3° to 77.0° F.; and during July 77.1 to 82.8° F. as given in table 1. The June temperatures ranged from 3 to 5° F. higher than those for Alliance[3] and Scottsbluff, but the mean July temperatures were only 1 to 3 degrees higher.

At North Platte the dry land plots were located about 200 feet above the irrigated plats and the temperatures there were a trifle lower.

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[2]L. L. Zook, Harry Weakley, Chas. McCoy, and Phillip Hoff cooperated in the conduct of these tests at North Platte.

[3]H. O. Werner. Performance of clonal strains of Triumph potatoes. I. Comparison of strains on dry land in western Nebraska. Am. Potato Jour. 17:66-80; 1940.

TABLE 1.—*Mean monthly temperature and inches of effective rainfall (½ inch or more in one day or two consecutive days) at North Platte during the years of the tests.*

Year	Month					
	Apr.	May	June	July	Aug.	Sept.
	Mean Monthly Temperature °F					
1931	49.7	58.1	75.5	77.6	73.8	71.0
1932	52.6	63.2	70.3	78.3	76.3	63.8
1933	49.2	57.8	77.0	78.3	71.6	69.2
1936	47.1	63.9	73.0	82.8	78.7	67.9
1937	48.1	62.8	68.3	79.0	79.7	66.9
1938	50.2	58.7	71.0	77.1	78.2	67.7
	Effective Rainfall, Inches					
1931	1.07	0	2.00	0.58	0	0
1932	1.42	2.60	2.16	6.08	2.07	0.69
1933	4.52	2.17	1.18	0.77	2.19	1.77
1936	1.16	2.33	1.11	0.71	0	0
1937	0.51	0	2.55	1.29	0	0.64
1938	3.60	3.00	2.24	2.55	1.20	5.02

Data from monthly weather reports of U.S.D.A. Weather Bureau.

Temperature and rainfall conditions at North Platte are fairly typical of a large portion of central Nebraska.

Psyllids are believed to have caused the extremely low yield of 1938 as they were very abundant in these plots during June of that year. They were not observed in other years, but they may have been present in some of the years, especially 1937. Dry-land plots at North Platte received from 3 to 12 inches of effective rainfall during the crop season as shown in table 1.

At North Platte earliest strains were generally the most productive when harvested about the 1st of August, when vines of early strains were almost dead but when those of the late strains were still green. If harvested one or two months later, the later strains were most productive. The earliest strains were the only dependable strains on dry land. These results are recorded in table 2. In some seasons the leaves of later strains were killed by tipburn in July, but their stems remained green until fall, sometimes producing a second crop of leaves.

TABLE 2.—*Test of strains of Triumph potatoes and other varieties at North Platte.*

Strain or Variety	1931		1932		1933		1936		1937		1938	
	Planting Date											
	April 20	April 20	April 20	April 20	April 21	April 21	April 21	April 21	April 14	April 14	April 18	April 18
	Harvesting Date											
	Aug. 11	Oct. 9	Oct. 1	Oct. 1	Aug. 8	Oct. 6	Aug. 3	Sept. 28	July 31	Oct. 8	Aug. 6	Aug. 6
	Type of culture and number and size of one row plats.											
	Irr. 6-50	Irr. 6-50	Irr. 12-50	Dry 3-50	Irr. 6-50	Irr. 6-50	Irr. 4-70	Irr. 4-70	Irr. 18-25	Irr. 18-25	Irr. 10-25	Dry 10-25
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
				Total Yield—Bushels per Acre								
Very Early	394	382			276	373	137	212	171	202	70	29
Early	398	400	363	166			112	204	168	256	52	22
Medium	362	373	355	165	255	408	111	208	163	271		
Late	388	407	331	110	261	403	103	203				
Very Late	356	425					85	236	139	202		
Irish Cobbler					229	436	230	354	227	364	169	50
Warba							218	258	222	246	140	40
Chippewa							153	312	118	279	51	9
Katahdin							57	176	81	278		
Rus. Rural							41	113				
Bu. required for significant difference							26**	50**	17.5**	46.7**	35**	11**
					U. S. No. 1 Grade—Bushels per Acre.							
Very Early	267	271			210	280	92	148	109	128	33	10
Early	264	284	332	123			81	142	97	161	20	3
Medium	243	261	324	103	190	281	75	145	93	177		
Late	249	293	307	62	160	282	72	135				
Very Late	243	289					52	166	56	167		
Irish Cobbler					185	292	200	267	175	264	124	28
Warba							159	115	147	148	92	16
Chippewa							98	244	64	206	21	1
Katahdin							26	122	34	194		
Rus. Rural							31	54				

**F values significant at 1 per cent level.

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Strain or Variety	1931		1932		1933		1936		1937		1938	
	Planting Date											
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	Aug. 11	Oct. 9	Oct. 1	Oct. 1	Aug. 8	Oct. 6	Aug. 3	Sept. 28	July 31	Oct. 8	Aug. 6	Aug. 6
	Type of culture and number and size of one row plats.											
	Irr. 6-50	Irr. 6-50	Irr. 12-50	Dry 3-50	Irr. 6-50	Irr. 6-50	Irr. 4-70	Irr. 4-70	Irr. 18-25	Irr. 18-25	Irr. 10-25	Dry 10-25
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
	Percentage U. S. No. 1 Quality and Size.											
Very Early	68	71			76	75	67	70	64	64	48	33
Early	66	71	91	74			73	69	57	63	39	13
Medium	67	70	91	62	75	69	69	70	57	65		
Late	64	72	92	56	71	70	71	66				
Very Late	71	68					61	71	40	57		
Irish Cobbler					65	67	87	76	77	73	74	55
Warba							73	44	66	60	66	41
Chippewa							64	78	54	74	40	5
Katahdin							45	69	61	73		
Rus. Rural							8	48				
	Percentage Rough Potatoes											
Very Early		2.6			7.6	21.5	6.9	6.0	6.4	3.5	0	0
Early		1.6				8.2	4.5	3.3	10.0	9.7	0	0
Medium		3.2			8.2		2.4	4.8	8.0	8.5		
Late		3.6			8.2	12.1	2.1	5.4				
Very Late		4.2				11.9	1.9	3.7	29.2	17.0		
Irish Cobbler						13.9	2.5	11.4	21.1	15.6	2.0	
Warba							9.6	29.5	12.3	15.7	0.7	0
Chippewa							0.9	1.8	0.7	3.0	0	
Katahdin							0	6.4	2.5	4.6		
Rus. Rural							0					

The earlier strains had the highest percentage of No. 1 potatoes. The percentage of rough tubers was greatest with the later strains with which it was sometimes relatively very high.

During several of the years the Triumph potatoes grown at North Platte cooked rather poorly; this was especially the case with the 1938 dry-land and irrigated crops.

The early yield of Irish Cobbler and Warba was generally greater than that of the earliest Triumph. The Irish Cobbler yield of No. 1 tubers was also greatest even though the percentage of rough tubers was very high. The yield of U. S. No. 1 Warba tubers was generally less than Triumph and always less than Irish Cobbler. The Warba frequently had many rough tubers. It is to be considered suitable only for very early use. The Chippewa, with good tuber quality, has much to recommend it if harvesting may be delayed. Katahdin and Russet Rural varieties were too late.

In comparison with the other early varieties, all strains of Triumph potatoes appear to be of dubious merit for central Nebraska. If any of them are to be grown there, only the earliest ones should be considered.

SECTIONAL NOTES

ALABAMA

Alabama's commercial potato acreage this year comprises 26,700 acres as compared with 24,300 acres for the past year. Of the total commercial acreage, Baldwin County has 22,000 acres.

The crop was planted during the first half of February. A period of cool weather followed, and on the 12th of April a heavy frost caused considerable damage to a large part of the acreage. Recovery has been satisfactory although the production will probably be reduced about 30 per cent and the shipping season delayed two weeks.

The weather in recent weeks has been very favorable for potatoes, and the quantity movement is expected to start between the 10th and 15th of May.

Our early estimates for Baldwin County were placed at 8,000 cars, but present estimates range from 5,500 to 6,000 acres.

The acreage of White Rose in South Alabama continues to

increase, approximately 12 to 15 per cent of the total acreage having been planted with this variety this season.

Increased facilities for washing and grading have been provided and the prospects at the present are that a good product will be handled, although the potatoes will run somewhat smaller than usual. (May 8).—L. M. WARE.

CALIFORNIA

Including the 8th of May, the shipments from Kern County this season are:

Edison	2506
Shafter	285
Arvin	113
Wasco	24
Total	2928

This compares with carload shipments to the same date last season of 1222 cars and in 1938, 679 cars. In other words, the District is shipping much earlier than usual, having shipped a much larger percentage of their crop than ever before at this date.

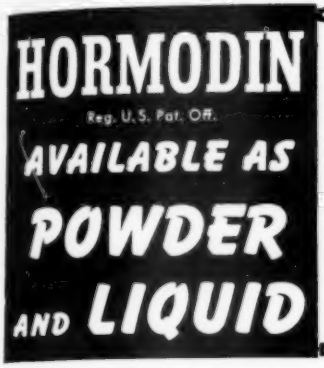
Our representative claims that from the original 9900 acres planted in the Edison/Arvin District there are now left about 2200 acres, which means that the average yield per acre will vary between 130 and 140 sacks.

Most people had anticipated a much heavier production but as can be readily observed, from the 7700 acres, the carload shipments, Edison and Arvin combined, were some where above 2600 to which might be added 25 per cent for truck shipments.

Of course the yields in Lerdo, Shafter and Wasco will undoubtedly run considerably heavier than the early acreages which are always considerably lighter than the other Districts.

There has been a great deal of Sepedonica damage prevalent to date which makes it really difficult to find potatoes which grade absolutely clean. What the growers will do to overcome this danger for another season is problematical, but it certainly appears very evident that something must be done.

So far the prices this season have been very satisfactory—U. S. No. 1 have been holding pretty well at $1.20/1.25, but with the heavier production in the later districts now beginning, it is expected that the market will gradually decline. (May 11).—E. MARX.



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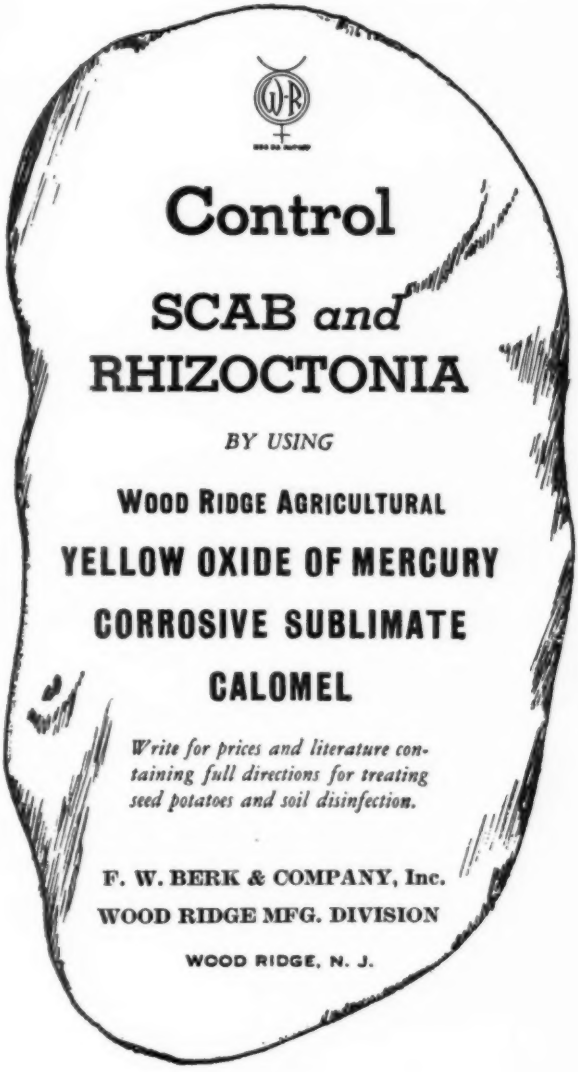
COLORADO

Plantings of potatoes in the earlier sections of Colorado, took place from the latter part of March to April. These early-planted potatoes are now coming up and the earliest of them will be harvested the last week in June and through July and August. Some of them will also extend into the early part of September. The late or main crop of potatoes is now being planted and these plantings will continue practically throughout the month of June. It is estimated that there will be an increase in Colorado of approximately 2 per cent in acreage of potatoes planted. This prediction was made quite early and will probably be quite accurate despite the fact that the outlook for growing conditions is probably the worst in several years. The soil is in excellent condition for planting in all areas of the state except the San Luis Valley. In this area it has been necessary for growers to flood the ground from their irrigation wells before planting. The winter snowfall has been far below normal, and the supplies of water in storage reservoirs at this time are only about one-half of what they were last year. Growers are very much concerned at this time about the prospective shortage of water. The heaviest precipitation for any month of the year in Colorado generally occurs in May. In 1935 the outlook was practically as bad as it is this year, at which time we received eight inches of rainfall during the month of May which filled up the storage reservoirs and assured a crop for that season. In 1936 the outlook was also quite bad at this time of year, but timely rains throughout the growing season produced a crop which was above average in yield. In 1939 the outlook was also bad at this time of year, and the May rains failed to materialize. Supplies of irrigation water became exhausted about the latter part of July. At that time rains started and we received a very heavy rain early in September. Frost occurred late, and a good crop, as far as yields were concerned, was obtained.

Hearings are now being held on a marketing agreement for the early districts in the state, concerning price postings, pro-rating of digging, and regulation of grades which can be shipped. After the hearings a vote will be necessary on the part of the growers under the new marketing agreement law which has been passed by the State Legislature, and was used very successfully last year on the peach crop. (May 10).—C. H. METZGER.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LOUISIANA

The potato crop of the Irish Cobbler variety in Louisiana is very irregular owing to adverse planting conditions. All plantings were made between the 10th of January and the 15th of March. The late growing season was very favorable and this undoubtedly will help the total tonnage and quality.

There were about 500 carloads of northern seed imported into the state. Most of the seed were certified Triumphs, but there were 60 carloads of certified Katahdins. Growers in the state planted about 35,000 to 40,000 acres, almost one-half of which will be used for local markets and farm consumption.

There are still too many lots of poor certified seed being shipped to Louisiana. I have checked several lots this week in which diseases ran from 20 to 25 per cent. Several cars of seed are showing some bacterial ring rot. One car, in particular, shows 10 per cent wilt caused by the bacterial ring rot organism.

Harvesting started lightly on the 6th of May, which is about two weeks later than normal. The first sales made were at $1.65 *per cwt.*, f.o.b. Louisiana points, for U.S. No. 1 Size A. Farm prices are now ranging from $1.00 to $1.25 *per cwt.* This is unusually low for early shipments and as a result most growers are harvesting lightly. Peak harvesting should be reached between the 20th and 25th of May.

Harvesting conditions have been ideal and the quality is very good. Estimates of the commercial crop of shipment are now placed between 2,700 to 3,000 cars. Many trucks are now buying potatoes for direct haul to market and this will undoubtedly reduce the carlot shipments. (May 11).—J. G. RICHARD.

TENNESSEE

Generally, spring conditions have been unfavorable for early planting of Irish potatoes over much of the state of Tennessee. Franklin County, located in the south-central part of the state, is expected to produce about a two-thirds normal crop. West Tennessee production will also be undoubtedly lowered by cold weather and too frequent spring rains. The producing potentialties of these areas are somewhat less than those of the Cumberland Plateau. Frequent sub-zero temperatures on the Plateau have frozen some of the stored seed during the winter months. It is probable that much of the frozen seed will not be replaced at the present price level of good seed stock. Considering these

factors and the poor planting conditions that also have been prevalent in this area, it is very doubtful if the expected increase in acreage will materialize. A lower total production for the state, as a whole, is predicted because of the reduced yields usually incurred from delayed plantings. (May 2).—D. M. BAILEY.

VIRGINIA

It was generally estimated that the white potato acreage on the Eastern Shore of Virginia would be reduced 15 per cent, as compared with 1939's 33,000 acreage. As the planting season progressed, many sources believed that there would not be so great a reduction as had first been indicated. Some sources still believe the reduction will be from 10 to 15 per cent; many others think it is not more than 5 per cent. It is probable that the latter figure is the most accurate.

The crop, as a whole, is looking very good. Generally speaking, from Onley south the stand is excellent. From Accomac north there will be some broken fields and a few breaks in many others, but apparently this is not a very serious condition.

All the Eastern Shore of Virginia is suffering from lack of moisture at this time, although the lower fourth of the Peninsula had a reasonably good rain last Friday.

At present there are no new activities in connection with marketing. Apparently the conditions that prevailed last year regarding marketing the crop, will prevail this season. (May 15)—G. S. RALSTON.

ERRATUM

In the April issue, in the article by Skaptason, Peterson and Blodgett, on page 90, the figures in table 3 under "Percentage germination of sporangia of *Phytophthora infestans*" the two numbers are interchanged; that is, the 50.4 should be opposite "Virgin soil" and 8.6 opposite "Old soil."

POTATO TOURS

The Maryland and Virginia Potato Tour and Field Day will be held on Tuesday, June 18. Visitors will assemble at the Pilchard Farm at Pocomoke, Maryland, at 8:30 a. m. and after visiting there, will

inspect several farms *en route* to the Eastern Shore Experiment Station at Onley.

The Seed Potato Certification Conference will be held at Cranbury, New Jersey, on Wednesday morning, June 19. Arrangements will be made to transport visitors from New Brunswick to Cranbury. This meeting will occupy the entire day but for those who care to do so, arrangements will be made to attend the meeting of the New Jersey Potato Growers' Association on the afternoon of the 19th. Seed potato certification officials and representatives from the various states have sent in diseased samples, which have been planted. Considerable material, therefore, is available for the study of some of the newer diseases.

The Long Island potato tour will be held on June 20 and 21. The tour will leave from Mineola near the Court House on Thursday morning at 9:30 a. m. and from the Henry Perkins Hotel, Riverhead, on Friday morning, June 21, at 7:30 a. m.

Complete information concerning the Virginia meeting may be obtained from W. O. Strong, Onley, Virginia; and information concerning the Long Island tour, from W. G. Been, Court House, Riverhead, or H. H. Campbell, 1507 Franklin Ave., Mineola.

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POTATO INSECT INVESTIGATIONS IN 1939

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A number of papers dealing with potato insect problems have appeared during the year 1939. In this review it is, of course, impossible to do justice to the many important findings published in these articles. A large part of the work has been done in this country particularly investigations of potato spraying and dusting. Many of the problems are, however, similar here and abroad.

Insects produce a diversity of injuries to the potato crop and may be loosely grouped into foliage feeders, tuber insects and vectors of diseases particularly the viruses. Foliage insects decrease yields through destruction of the foliage, tuber insects reduce the market quality of the crop and insect vectors spread many important seed borne diseases. Hallock (11) recorded six species of fleabeetles on potatoes in Pennsylvania but only two species, *Epitrix cucumeris* and *Epitrix parvula*, were abundant. Other insects in the first group were the familiar Colorado potato beetle, *Leptinotarsa decemlineata*, the potato leafhopper, *Empoasca fabae*, and the psyllids, *Paratrioza cockerelli* and *Paratrioza mexicana*. Tuber insects of importance were wireworms of various species and the potato tuber moth, *Phthorimoea operculella*. Insects associated with virus diseases included aphids, chiefly *Myzus persicae*, and the clover leafhopper, *Aceteragallia sanguinolenta*.

Spraying and dusting for insect and disease control have long been established practices in most potato-producing areas of this country. Bordeaux and copper-lime are the standard materials used and serve a dual purpose as a fungicide and insecticide. Im-

provements in the application schedules and the inclusion of more efficient insecticides in sprays and dusts have been recommended from time to time. In eastern Virginia, Anderson and Walker (2) reported that a Bordeaux and calcium arsenate spray was more effective against potato fleabeetles than sprays of insoluble coppers and rotenone bearing powders. Gui (10) also recommended the inclusion of calcium arsenate in Bordeaux spray and copper-lime dust. His recommendations were based upon a number of experiments conducted during a four-year period. Bourne (3) found, however, that the addition of rotenone-bearing powders, cubé and derris, and calcium arsenate to Bordeaux spray did not increase yields. In New York State (19) pyrethrum and sulphur dusts applied to Bordeaux-sprayed plots did not materially increase yields over similar undusted plots. The additive control of fleabeetles and leafhoppers by the dusts was not correspondingly reflected in yields. Experimental results are not in agreement as to the benefits derived from the inclusion of arsenicals, pyrethrum or rotenone materials with Bordeaux sprays and work along this line should be continued.

Increases in yield from spraying and dusting have been correlated with stimulation of plant growth by copper, magnesium, and other essential elements and by the control of one or more of the injurious insects and diseases. After surveying the mass of data accumulated from many spraying experiments MacLeod (17, 18) raised the question of the adequacy of our field methods for the determination of insect damage to foliage by the use of the tuber yield. He pointed out the difficulties of evaluating each of the many factors affecting this final tuber yield which is used as the ultimate criterion of any treatment. The need for more precise methods of measuring plant reactions to insect feeding is apparent and he suggested a basic study of the effects of insect injuries to plant physiological processes.

A promising new arsenical, basic copper arsenate, was reported by De Long and co-workers (8). It compared favorably in toxicity with calcium and lead arsenates and was not so injurious to foliage as the former. It gave excellent control of the Colorado potato beetle and when used with sulfur controlled leafhoppers effectively.

The Colorado potato beetle, a native and familiar pest in this country, was introduced into France a few years ago. Its spread over a large area of western Europe has caused considerable alarm as a threat to a vital food crop. Early attempts of eradication have

been replaced more recently by investigations on effective measures of reducing infestations. Calcium cyanamid (7) applied to the soil infested with hibernating beetles reduced emergence about forty-five per cent. Laboratory and field tests (26) with calcium arsenate, pyrethrum and derris sprays and dusts were effective in controlling both beetles and larvae. These materials are regularly used in this country for the control of the Colorado potato beetle.

Considerable attention was given to the potato psyllid. This insect is exceedingly injurious in many potato producing areas in the central and western states. Infested potatoes develop psyllid yellows and fail to provide a normal crop. Janes (14) made observations in Texas and found the insect widely distributed in that state. Dry lime sulphur and sulphur dusts gave satisfactory control. Temperature relations were studied by List (16) who found that high temperatures inhibited the development of potato psyllids. In certain regions of Colorado psyllids disappeared during the hot part of the summer and reappeared when temperatures became favorable. Romny (24) believed that psyllids migrated from wild host reservoirs in Arizona to reinfest these particular regions in Colorado.

From time to time the resistance or susceptibility of potato varieties to insects has been recorded in the literature. Allen and Rieman (1) measured the amount of hopperburn, the injury caused by the potato leafhopper, to several varieties of potatoes. In general the early maturing varieties were more susceptible than late maturing varieties. Some resistant seedling selections were made for further testing.

Of the tuber insects recorded in the recent literature wireworms received the most attention. Wireworms were found attacking a number of crops including potatoes in Russia (21) and Calcium cyanide was used with success as a soil treatment (15). Miles (20) warned growers in England against planting potatoes after infested sod land for at least a three-year period. Hawkins (12) in this country recommended a rotation of cultivated crops for the control of the wheat wireworm, *Agriotes mancus*. Strickland (28) studied the life history and food requirements of the northern grain wireworm. He found that the newly hatched wireworms were very susceptible to starvation but older wireworms were more difficult to starve out. Campbell and Stone (5) attempted to reduce wireworm populations by trapping the beetles. Although large numbers of beetles were destroyed the wireworm infestations were not re-

duced. Gibson (9) studied wireworm damage to potato crops in the Yakima Valley of Washington and found a correlation between the amount of damage and the wireworm population. He concluded that two wireworms to a square foot of soil are the maximum number that can be tolerated for commercial potato growing. The author (25) noted a relation between planting dates and injury by the eastern field wireworm in New York. Late-planted potatoes were not injured so severely as early-planted ones.

Two other tuber defect problems were recorded. Prescott (22) studied the distribution of the tuber moth in the Victoria Province of Australia and recommended control measures. Cameron (4) found damage by the grey field slug prevalent in Scotland and discussed methods of control.

Insects were important in the spread of virus diseases. Simpson (27) obtained transmission of leaf roll by the green peach aphid, *Myzus persicae*, but not by the potato aphid, *Macrosiphum solanifolii*. A heavy infestation by the former in Maine accounted for the heavy spread of leafroll in 1937. Profft (23) studied the influence of wind drifts in the dispersion of aphids in potato fields and found that they collected in greater numbers in sheltered fields than in exposed fields. Davies (6) surveyed selected districts of Scotland and found three possible aphid vectors of virus diseases. Watkins (30) studied the life history and control of the clover leafhopper, the vector of potato yellow dwarfs. (29). Pyrethrum dusts gave better control of the leafhopper than Bordeaux spray but was not reflected in reduction of yellow dwarf.

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RELATION OF SOME GROWTH CHARACTERS TO STOLONIFEROUS CONDITION IN SEEDLING IRISH POTATOES[1]

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It has been observed that a wide range of stolon development and top growth occurs in seedling progenies from crossed and selfed lines, grown under natural-spring conditions at Baton Rouge, Louisiana. This range was great enough to permit groupings corresponding to practically all the types reported in the investigations dealing with long- and short-day varieties grown under controlled conditions of light, and temperature (4) These types seemed to be usually associated with certain definite stages of other growth characters.

The present investigations were made to determine: (1) the degree of association between type of stolon development and (2) the expression of certain other growth characters that would serve as criteria in selecting high-yielding seedlings.

METHODS AND MATERIALS

Crossed and selfed lines of true seed were produced during the spring breeding seasons of 1937-'38. These crossings and selfings were made without emasculation or bagging, but in making the crosses care was taken to use only those flowers whose anthers were not ready to dehisce. The true seed was harvested during the last two weeks of May, cleaned and stored until the middle of July. About the 20th of July of each year the seed was planted in steamed soil in metal flats. From the 15th of August to the 19th of September, the seedling plants were transplanted to 3-inch pots. After attaining a height of 3 to 4 inches they were transplanted into the field.

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Tubers were harvested about the 10th of December, at which time samples were taken from each segregate within each progeny for spring planting. In the spring, individual tubers of the progenies were planted. All the progenies received comparable fertilization and cultivation.

Harvesting data were taken when the degree of maturity among the individuals, as a whole, was advanced enough to allow satisfactory designation as to early-, medium-, and late-maturing groups.

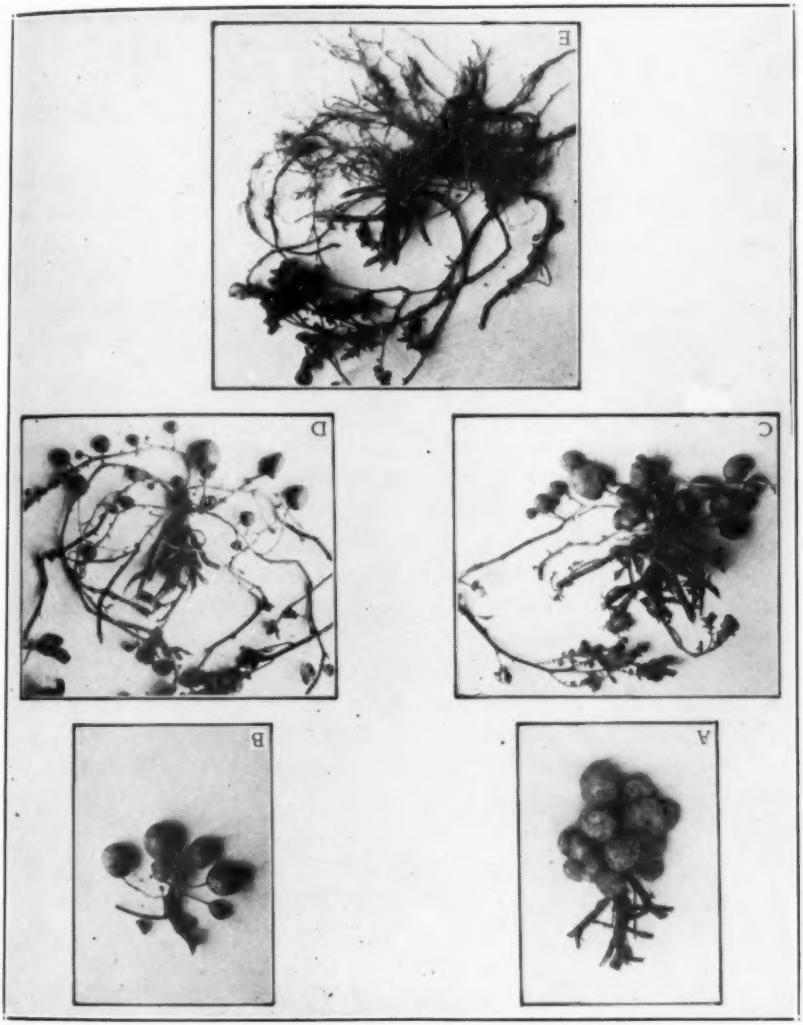

FIGURE 1—FIVE TYPES OF STOLON DEVELOPMENT. A. Basal set. B. Tuberous. C. Slighty stoloniferous. D. Stoloniferous. E. Completely stoloniferous.

Heat sprouting, as herein used, is a premature sprouting of tubers. It is frequently associated with short-rest periods, and sprouting usually occurs at the apical end. No consideration was given to the extent of sprout development.

Stoloniferousness, as herein used, is the expression of the tendency of potatoes to produce vegetative or non-tuberizing stolons, and to develop multiple tubers on those stolons which tuberize. The plants studied were grouped into five types of stoloniferousness as follows:

1. *Basal set*—setting of tubers very close around the basal end of the main stem with very short or no intervening stolons. (Figure 1A).

2. *Tuberous*—Only one tuber per stolon and no excessive stolon development. (Figure 1B).

3. *Slightly stoloniferous*—some stolons bearing more than one but less than four tubers and the presence of some excessive stolon development (Figure 1C).

4. *Stoloniferous*—numerous small tubers produced, with some stolons bearing four or more, and decidedly over-developed system of stolons (Figure 1D).

5. *Completely stoloniferous*—very excessive stolon development to the exclusion of tuberization (Figure 1E).

In determining the response of a given progeny, each plant was classified as to stolon type according to the criteria discussed above. Plants of the same stoloniferous type within a progeny were grouped and the total number in each group recorded. From these data the average stoloniferous index for each progeny was calculated, which is the ratio of the total sum of products of each stoloniferous type by the number of plants contained therein, to the total number of plants in the progeny. These average stoloniferous types were used as indices of relative stoloniferousness. Thus in the case of Sebago x Katahdin in 1939, no plants were of type 1; 42 were of type 2; 24 resembled type 3; 8 type 4; and 4 resembled type 5. The average stoloniferous type was computed as follows:

$$\frac{(0 \times 1 = 0) + (42 \times 2 = 84) + (24 \times 3 = 72) + (8 \times 4 = 32)\ (4 \times 5 = 20) =}{78}$$

$$\frac{208 = 2.67}{78}$$

The value of 2.67 then equals the index of average stoloniferousness for the Sebago x Katahdin progeny in 1939.

Experimental Data

Relation of Stolon Development to Degree of Maturity

The percentage distribution of each progeny studied relative to degrees of maturity is presented in table 1. Average stoloniferous

Table 1—*Relation of type of stoloniferousness to degree of maturity in some Irish potato progenies grown in the field at Baton Rouge, Louisiana, in* 1938 *and* 1939

Cross[1]	Year	Distribution (Per Cent) As to Maturity			Index of Stoloniferousness		
		Early	Medium	Late	Early	Medium	Late
Earlaine x Katahdin	1939	13.5	35.1	51.4	2.00	2.15	3.68
Triumph x Katahdin	1938	27.3	45.4	27.5	2.42	2.95	4.42
	1939	15.6	33.3	51.1	2.03	2.71	3.74
Prince Albert x Earlaine	1938	33.3	43.2	23.5	2.52	2.94	3.89
Sebago x Katahdin	1939	10.3	50.0	39.7	2.13	2.23	3.36
Early Rose x Katahdin	1938	25.0	38.3	36.7	2.10	2.46	3.36
Prince Albert x Katahdin	1938	34.8	36.7	28.5	2.42	2.90	3.87
	1939	17.5	34.9	47.6	2.09	2.36	3.57
Earlaine selfed	1938	52.8	41.5	5.7	2.14	2.32	2.33
Early Rose x Earlaine	1938	39.0	53.7	7.3	2.69	2.41	4.67
No Blight x Katahdin	1938	7.3	19.7	73.0	2.70	3.15	3.64

[1]The small progeny in this study contained 37 segregates; all others exceeded this and the maximum was 670 for Triumph x Katahdin in 1939.

indices are also given for each class of maturity within each progeny. It is apparent that the maturity from earliness to lateness is directly and positively associated with an increase in stolon development from a tuberous type to a complete stoloniferous type. For example in the progeny of Triumph x Katahdin the average stoloniferous index for the early-maturing group in 1938 was 2.42; in the medium-maturing group it was 2.95; and in the late-maturing 4.42. A similar relationship was obtained with all of the progenies studied.

Experience indicates that the most promising seedling selections are found in either the early- or medium-maturing groups. Since a high percentage of the segregates in the late-maturing group approach complete stoloniferousness, very few approach a commercial type.

Correlation between Stolon Development and Height of Plant

The degree of association between the type of stolon development and the height of plant in the progenies studied is given in table 2.

Table 2—*Correlation between type of stoloniferousness and height of plant in some Irish potato progenies grown under field conditions at Baton Rouge, Louisiana, in* 1938 *and* 1939

Cross	Number of Segregates		Correlation between Height and Stoloniferousness	
	1938	1939	1938	1939
Earlaine x Katahdin	—	37	—	+0.84**
Triumph x Katahdin	43	670	+0.76**	+0.59**
Prince Albert x Earlaine	79	—	+0.56**	—
Sebago x Katahdin	—	78	—	+0.55**
Early Rose x Katahdin	120	—	+0.52**	—
Prince Albert x Katahdin	137	63	+0.43**	+0.56**
Earlaine selfed	52	—	+0.39**	—
Early Rose x Earlaine	43	—	+0.35*	—
No Blight x Katahdin	136	—	+0.29**	—

*Significant at the 5 per cent point.
**Significant at the 1 per cent point.

A significant degree of association between stolon development and height of plant was found in all the progenies studied. Therefore, generally the taller the plant the greater the degree of stoloniferousness. Short plants or plants of medium height generally produced more tubers. The Triumph x Katahdin progeny had a correlation coefficient of +0.76 and +0.59 in 1938 and 1939, respectively; the latter coefficient being based on a relatively large population. On the other hand, the No Blight x Katahdin progeny had a correlation coefficient of only +0.29 in 1938.

Correlation between Stolon Development and Maximum Length of Stolon

The degree of relationship between stolon development and maximum length of stolon for each of the nine progenies studied is presented in table 3.

Table 3—*Correlation between the type of stoloniferousness and length of stolen in seedling Irish potato progenies grown under field conditions at Baton Rouge, Louisiana, in* 1938 *and* 1939

Cross	Number of Segregates		Correlation between Maximum Stolon Length and Stoloniferousness	
	1938	1939	1938[1]	1939[1]
Earlaine x Katahdin	—	37	—	+0.92
Triumph x Katahdin	43	667	+0.90	+0.67
Prince Albert x Earlaine	81	—	+0.84	—
Sebago x Katahdin	—	78	—	+0.80
Early Rose x Katahdin	120	—	+0.83	—
Prince Albert x Katahdin	207	63	+0.83	+0.77
Earlaine selfed	54	—	+0.71	—
Early Rose x Earlaine	41	—	+0.63	—
No Blight x Katahdin	133	—	+0.59	—

[1]All values exceed the 1 per cent point.

The correlation coefficients for the majority of the crosses indicate a high degree of association between stolon development and maximum length of stolon. It is, therefore, evident that as the maximum length of the primary stolon increased, the number of tubers produced decreased.

Relation of Stolon Development to Heat Sprouting of Tubers

The percentage of heat sprouting in each stoloniferous-type group of each progeny studied is given in table 4.

TABLE 4—*Relation of type of stoloniferousness to heat sprouting of tubers, under field conditions at Baton Rouge, Louisiana, in* 1938

Cross	Number of Segregates	Heat Sprouting (per cent) at Each Type of Stoloniferousness			
		1	2	3	4
Triumph x Katahdin	49	0.0	13.3	14.3	75.0
Early Rose x Katahdin	114	—	34.3	50.0	60.0
Prince Albert x Katahdin	206	0.0	31.2	55.6	72.7
Earlaine selfed	53	20.0	29.4	63.6	33.3
Chippewa selfed	63	—	18.2	22.2	0.0
Houma x Katahdin	66	—	12.9	28.6	28.6
No Blight x Katahdin	125	—	9.1	27.5	46.0

The greatest degree of heat sprouting of the crosses studied occurred in the stoloniferous-type group (type 4), whereas, in the selfed progenies heat sprouting was most prevalent in the slightly stoloniferous-type group (type 3).

DISCUSSION

In order to obtain high-yielding clonal lines of Irish potatoes it is desirable, under Louisiana conditions, to select first-year seedling segregates having tuberous to slightly stoloniferous types of stolon development. The association of any top-growth characters with underground systems of development would be useful in a breeding program where superior yielding strains are being selected. The results of the progenies studied indicate that the maximum height of the plant and the earliness of maturity are closely associated with the above two types of stolon development mentioned. Therefore, these two characters may serve as criteria for the selection of high-yielding segregates.

SUMMARY

1. A number of progenies from selfings and crosses of Irish potatoes were studied to determine the differences in the degree of stolon development and the relation of stolon development to certain other growth characters, under field conditions at Baton Rouge, Louisiana.

2. As the degree of maturity increased from early to late, tuberization decreased accordingly.

3. In general, the degree of tuberization decreased as the maximum height of plant and as primary stolon length increased.

4. In the crosses studied, heat sprouting increased as stolon development progressed from a tuberous to a less tuberous condition. However, in the 2 selfings studied maximum heat sprouting occurred at a higher level of tuberization than that for the crosses.

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LONGEVITY OF POTATO SEED

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In the search for new material which the potato breeder may wish to utilize in his program of potato improvement, or in going back to unused portions of seed lots to increase the size of progenies which may have already been produced, it is sometimes desirable to make use of seed which has been stored for some time. Several experiences have indicated that the vitality of potato seed stored under ordinary conditions is of relatively short duration.

To obtain more definite information on this point, as well as to determine whether conditions may be found which will prolong the life of potato seed, the experiments described in the following pages were planned.

The material for the first test consisted of several ounces of seed harvested in 1922, from naturally pollinated plants of an unnamed seedling variety, designated as S 39477, which was grown in the field at Presque Isle, Maine. This variety produced seed balls in great abundance. The seeds were placed in a bottle which was tightly corked but not sealed, and stored in the office files of this Division in Washington.

Each spring, early in April, a sample consisting of 300 to 600 seeds was taken from the bottle and a germination test made. The tests were

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made in soil in 6-inch unglazed clay pots. The pots were nearly filled with a prepared soil consisting of equal parts of fine compost and sand. The pots were then watered, the seeds planted and covered to a depth of approximately ⅛ inch with fine river sand.

To maintain the moisture supply as uniformly as possible the pots were covered with glass to which was added a covering of paper to exclude sunlight. The coverings were removed as soon as the plants appeared above ground.

The germination tests were conducted in the greenhouse at Presque Isle, Maine. The temperature was maintained at approximately 70° F. during the day, or somewhat higher during periods of sunshine, and from 50° to 55° at night. These conditions are the same as those under which the seedling plants used for the potato breeding work at that station are started.

The germination readings were taken three to four weeks after the seeds were planted. All sprouts which appeared at or above the surface of the ground were recorded regardless of whether they made subsequent growth.

The tabulated results given in table 1, column 2, show that after four years of storage the viability of the seed began to diminish and continued to do so, until at the end of ten years the seed was non-viable.

To determine whether different conditions of storage would affect in different degrees the viability of the seed, another series of tests was started. For this purpose seed resulting from the natural pollination of an unnamed seedling variety, S 42487, was saved in the autumn of 1926. The seed was divided into four lots of equal size and on the 1st of December placed in different storages as follows:

Lot 1, stored in a heavy manila envelope, at room temperature, in office files.

Lot 2, stored in bottle, at room temperature, in office.

Lot 3, stored in bottle, at 40° F.

Lot 4, stored in bottle, at 32° F.

The bottles were fitted with tight cork stoppers but not sealed.

The temperature of the room in which Lots 1 and 2 were stored varied from 65° to 75° during the winter and from 85° to 90°, or occasionally higher, in summer. After 1935 these lots were stored in the attic where the winter temperatures were approximately 15° lower than those which prevailed in the office. The temperature of the 40° and the 32° rooms was maintained within maximum fluctuations of ± 1°.

The humidity of the room storage fluctuated considerably according

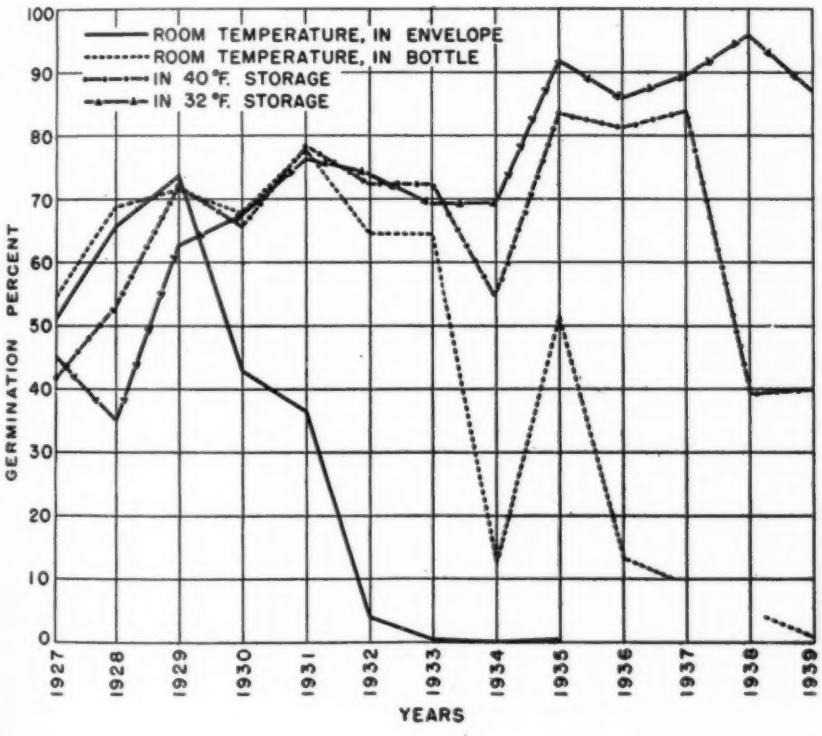
to the varying weather conditions, but the climate of Washington, D. C., is considered as being relatively high in humidity.

The humidity of the 40° F. storage was approximately 80° and the 32° room 80° to 85°.

Beginning with the spring of 1927 yearly germination tests were made. Samples of 400 seeds were drawn from each treatment, divided into duplicate lots of 200 seeds each, and tested in the manner described for S 39477. The results are given in table 1 and shown graphically in figure 1.

These data indicate very clearly the influence of storage conditions on the longevity of potato seed. These influences, however, apparently did not begin to operate until after the third year of storage, since the germination of all lots was distinctly higher at the time of the third test in 1929. After that time a difference began to appear in the lots stored under different conditions.

FIG. 1.—*Germination of potato seed stored under 4 conditions during the period 1927 to 1939, inclusive*



Of the four conditions under which the tests were conducted, the loss of viability was greatest in the lots stored at room temperature, the most rapid deterioration being in the lot stored in the paper envelope in which the germination was reduced to a very low point after five years.

TABLE 1. *Germination of potato seed from two sources, covering periods of* 10 *and* 13 *years, respectively*

Year	S 39477	S 42487			
	Room Temperature In Bottle	Room Temperature		Cold Storage	
		In Envelope	In Bottle	40°	32°
	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
1923	64.33				
1924	43.33				
1925	61.67				
1926	47.03				
1927	23.50	51.25	54.75	41.75	45.00
1928	11.50	65.75	68.75	53.00	35.00
1929	7.25	73.75	71.75	72.00	62.50
1930	4.50	43.00	67.75	65.75	67.50
1931	3.00	36.50	78.25	78.50	76.25
1932	.50	4.00	64.75	72.50	74.00
1933		.50	64.50	72.50	69.25
1934		.00	12.75	54.25	69.50
1935		.50	51.50	83.50	91.75
1936			13.50	81.25	86.00
1937			*	84.00	89.50
1938			*	39.25	96.00
1939			.75	40.00	87.00

*No test.

In the lot stored in the bottle at room temperature, a fairly high level of germination was maintained for nine years. The longevity of this lot was somewhat greater than that of S 39477, which was kept in the same kind of storage. A comparison of the germination records of the two varieties given in table 1, shows that the germinability of S 39477 was slightly lower than that of S 42487, thus indicating a lower vitality which possibly accounts for its more rapid deterioration.

The germination of the two lots stored at low temperatures very closely followed the same trend during the first seven years of the test. From 1934 to 1937 the germination of the 40° F. lot was slightly lower than, though parallel with, that of the lot stored at 32°. The 1938 and 1939 tests showed a decided drop in the viability of the seed stored at 40°, indicating that this lot had begun to deteriorate, whereas the seed held in the 32° storage still maintained its ability to give a high percentage germination. The low temperature of 32° not only inhibited deterioration but apparently had a stimulating effect, since the germination was maintained at a higher level during the 9th to the 13th years of storage than was obtained in any other period of the test.

The significance of the results obtained in these tests is shown by the F values recorded in table 2, the values for both years and treatments, considered separately, being so large that there is not one chance in a

TABLE 2. *Analysis of variance for germination of potato seed subjected to 4 treatments for 10 years and for 2 of the treatments for 13 years*

Sources	10 Years, 4 Treatments		13 Years, 2 Treatments	
	Degrees of Freedom	F	Degrees of Freedom	F
Years	9	18.43	12	20.007[1]
Treatments	3	147.23	1	24.310[1]
Replicates	1	Less than 1	1	Less than 1
Years x treatments	27	20.18	12	11.288[1]
Error	39		25	
Totals	79		51	

[1]Exceeds the 1 per cent value for F.

hundred that the differences are due to experimental variability. The uniformity of the duplicate samples is shown by the low F values for replicates.

The interactions between years and treatments, the F value for which exceeds that of the 1 per cent level, indicates that there is a significant difference in the response of seed of different ages to the conditions under which it is stored.

Other investigators have reported results which indicate the value of low temperatures in prolonging the life of seeds. Isaac (2) found that seed of noble fir, which loses most of its vitality after the first year when stored at room temperatures, suffered no appreciable loss of vitality when held at a temperature of 15° F. for a period of five years. The highest germination occurred after the fourth year.

Beattie and Boswell (1) found that onion seed stored in sealed containers at 20° F. showed no significant loss of vitality at the end of seven years, while seed stored at room temperatures rarely retains sufficient vitality to be of commercial value more than two years.

CONCLUSIONS

Yearly tests were made of potato seed stored for a period of thirteen years under four conditions; viz.,

(1) In envelope, at room temperature.
(2) In bottle, at room temperature.
(3) In bottle, at 40° F.
(4) In bottle, at 32° F.

Storage at room temperature was decidedly inferior to cold storage in maintaining the viability of the seed. The envelope container was the least efficient of all storages.

Seed stored at 40° F. showed no decline in viability until after 11 years of storage.

The 32° F. temperature not only prolonged the life of the seed to the end of the 13-year storage period, but appeared to have a stimulating effect, since the highest percentages of germination in this lot were obtained during the last five years of the test.

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PERFORMANCE OF CLONAL STRAINS OF TRIUMPH POTATOES

IV.

COMPARISON OF TRIUMPH STRAINS IN EASTERN NEBRASKA (AT LINCOLN) WITH AND WITHOUT IRRIGATION

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At Lincoln potatoes are planted in early part of April. Therefore, the plants emerge when days are about 13½ hours long and temperature is about 50° F., but days become longer and warmer as the season advances (see table 1). Generally speaking, the early varieties develop most of the crop by the early part of July. The adaptability of a strain or variety is determined by its ability to produce tubers early or in hot weather, or for the leaves to resist tip burning.

TABLE 1.—*Mean monthly temperature at Lincoln during the four trial years,* °F.

Year	April	May	June	July
1931	55.0	62.2	78.2	80.2
1936	48.4	67.0	74.0	87.4
1937	49.6	63.4	72.2	80.4
1938	52.2	59.2	72.0	80.3

From monthly reports of U.S.D.A Weather Bureau.

In 1938 psyllids did considerable damage during June when temperatures were lower than usual. This pest is rarely present in sufficient numbers at Lincoln to cause serious damage. Seed potatoes for these trials at Lincoln were produced in the dry-land plots at Alliance.

The very early strain always outyielded the early one at Lincoln. It also produced a much higher percentage of No. 1 tubers. In the one year when used and in other small scale tests the midseason and late strains have not produced satisfactory yields (see table 2).

[1]Published with the approval of the Director as Paper No. 241. Journal Series, Nebraska Agricultural Experiment Station.

TABLE 2.—*Test of strains of Triumph potatoes during four years at Lincoln either with or without the use of irrigation water.*[1]

Triumph Strain or Variety	1931	1936		1937				1938
	Apr. 6	April 1		April 8		April 8		April 3
	Aug. 7	July 6	July 21	July 17	Aug. 25	Aug. 17	Aug. 25	Aug. 1
	(6-50) Dry	(4-25)[2] Irr.	(5-25) Irr.	(9-25) Irr.	(9-25) Irr.	(9-25) Dry	(9-25) Dry	(20-25) Irr.
				Total Yield—Bushels per Acre				
Very Early	101	190	180	350	317	259	261	197
Early	98	162	174	216	236	168	161	150
Medium	84							
Late	81							
Very late	85							
Warba		343	309	341	329	223	210	257
Irish Cobbler		190	182	287	305	199	200	216
S. Dif.	18.6*	52**	25**	43**	37*	41**	49*	26**
				U. S. No. 1 Quality—Bushels per Acre				
Very Early	37	104	90	237	227	157	164	106
Early	43	78	77	134	158	87	83	84
Medium	34							
Late	32							
Very late	31							
Warba		215	206	271	268	152	155	174
Irish Cobbler		119	93	219	227	138	149	145
				Percentage U. S. No. 1 Quality				
Very Early	36	52	50	68	72	61	62	47
Early	44	48	44	66	67	52	52	48
Medium	40							
Late	39							
Very late	37							
Warba		72	65	80	81	69	74	68
Irish Cobbler		63	51	76	74	69	74	67

*F Values significant at 5 per cent level. **F Values significant at 1 per cent level.

[1]Precipitation for April, May and June was as follows: 1931—14.72 in.; 1936—5.09 in.; 1937—7.03 in., and 1938—12.19. Irrigation in addition to rainfall was 15 in. in 1936; 12 in. in 1937, and 6 in. in 1938.

[2]Number of single row plats with given number of hills.

The leaves of the very early strain burned severely a week or so before those of the early strain, but tuberization having occurred earlier with the very early strain, this leaf burning did not cause sufficient damage to reduce the yields below those of the early strain. Leaves of the midseason strain held up still longer, but yields of this strain have been very unsatisfactory. The cooking quality of all strains of Triumph potatoes produced during hot summers has been unsatisfactory.

During the last three seasons when Warba and Irish Cobbler were grown in the same tests, the Warba was generally most productive although sometimes outyielded by the very early strain of Triumph. Irish Cobbler was generally slightly less productive than the very early Triumph strain, but more productive than the second-early strains. It commonly surpassed both Triumph strains in production of U. S. No. 1 grade potatoes, the percentage of tubers falling in this grade being greater because of fewer but larger tubers on each hill. Because of this and the better cooking quality, Irish Cobbler or Warba is more desirable than either of the Triumph strains for the production of potatoes in this region where tubers mature in very hot weather.

SECTIONAL NOTES

CALIFORNIA

The Shafter Market to date has been very erratic, and especially so, for the last thirty days.

On the 11th of May the market was $1.15/1.25 on U. S. No. 1 grades; the market advanced rapidly and reached a top of $1.90 on the 29th of May.

The market then started slipping and had reached a bottom on the 6th of June—of 95c.

Since then, there has been a new advance and the market today is $1.30/1.35.

Reports of light yields in Alabama and South Carolina were responsible for the spirited advance—which ended Decoration Day; then, an almost total lack of demand and buying power caused a precipitous decline which hit a low on the 6th of June. Whether or not the present advance is false or will be maintained—only history can tell.

On the 7th of June, the growers estimated 7150 acres remained for harvest of a total acreage in the Arvin/Edison/Lerdo/Saco/Shafter/Wasco areas of 27,249 acres for the 1940 season. Roughly speaking,

[1]Precipitation for April, May and June was as follows: 1931—14.72 in.; 1936—5.99 in.; 1937—7.03 in., and 1938—12.10. Irrigation in addition for rainfall in 1936, 12 in., in 1937, and 6 in. in 1938.
[2]Number of single row plots with plants in number of hills.

this should result in approximately 4,000 cars by rail and 1500 cars by truck for the balance of the season.

The Shafter potatoes—generally speaking—are still giving considerable trouble on account of sepedonica and only those fields where disease-free seed was planted, are getting clean certificates.

The total shipments from the District including the 9th of June were 8666 cars compared with 7215 cars through the 9th of June in 1939—and a total of 12,775 cars for last season.

The deal should clean up earlier than usual this year, with only a small amount held over into July. (June 11).—E. MARX.

CONNECTICUT

Water-logged soils are prevalent in many potato fields or parts of fields in Connecticut. This condition has resulted from excessive April precipitation, the cloudiest May in fifty years, and a three to four-inch rain on the 31st of May. In consequence, much seed is rotting in the ground and one thirty-acre field has been reported as being entirely ruined. It is too early to estimate how much damage has been caused by the very wet weather. (June 13).—B. A. BROWN.

MAINE

There seems to be a considerable difference of opinion concerning the potato acreage in Maine this year. Government figures forecast an increase of about 5 per cent, but the records of the Agricultural Conservation Association do not bear this out. In fact, all available information to date indicates the acreage will not be increased at all compared with last season. Since photographic maps have been made of all fields, and these can be checked accurately for acreage, the records thus obtained should be more nearly correct than estimates obtained in other ways.

As a matter of fact the acreage last season had not increased above the previous year, although the Marketing Service reported a 2 per cent increase. Yields and shipments, as they reflected yields, did not bear out this increase either, so there is much reason to question if the acreage in Maine this year totals more than 160,000.

The crop was planted hurriedly this year, and under rather adverse conditions. Very little planting was done before the fifteenth and it was about completed by the 1st of June. Better seed was used than ever before, taking the state as a whole, and there has possibly been a slight

increase in the amount of fertilizer used per acre with a considerable number of growers.

At the date of writing, the 15th of June, the weather continues rainy and cool. Since the first of June we have had a large amount of water which has not yet caused much damage, probably, but has delayed cultural operations materially. Because of the lower temperatures, plants have been developing an excellent root growth but are just now beginning to appear above ground in the earlier plantings.

It is too early, at present, to state the total acreage entered for certification, but expectations are that it will be as large, if not larger, than a year ago.

Shipments for Maine have now totaled slightly more than 37,000 cars and from now on the car lot movement will be very light. This elimination of competition from Maine shoould be helpful to the early states in cleaning up their supplies. It would be a helpful thing if this were done annually.

Grants of aid for lime under the Agricultural Conservation program were made available this year to Aroostook farmers as has been the case for the two preceding years to the other counties in the state. Many farmers have taken advantage of this.

In driving around through Aroostook at the present time, however, there is much evidence of further need for lime as sorrel is all too plentiful; sorrel being a pretty good indicator of undue acidity.

It will be of interest to many to know that two large marketing organizations have consolidated operations this spring, effective as of the 1st of July, namely Maine Potato Growers', Inc. and the American Fruit Growers', Inc. By this agreement the American Fruit Growers', Inc. are closing their Maine office and Maine Potato Growers', Inc. have the additional terminal facilities provided by the Blue Goose organization. It is encouraging to all interested in the development of sounder marketing of potatoes to find this growers' organization increasing in strength and resources with each passing year. (June 15).—FRANK W. HUSSEY.

NEBRASKA

Conditions of the Nebraska crop apply to seed beds, particularly because planting is in full force at this time. Growers as a whole, through western Nebraska, where the major potato acreage is located, are planting earlier than usual. Potato planting generally starts about the 10th of June, whereas this season a number of growers were planting before the first of June, and the bulk of them, shortly after the

first. This earlier planting was caused by poor prospects, particularly from the moisture standpoint. Fairly good rains prevailed throughout the territory during April, but from the 20th of April to the first of June, no rainfall was recorded. This long period without any precipitation was extremely trying on other crops, and growers were worried that with the advent of warmer weather the little moisture in reserve would be lost.

During the past few days, fairly good rains have fallen throughout most of western Nebraska. The seed beds are in ideal condition for planting at this time. Certain growers have been greatly concerned, because there is a shortage of water in the reservoirs on which they depend for irrigation during the summer months. This irrigation condition compares with 1934 in which the water supply was very scarce, and yields under irrigation were approximately one-third of normal. The crop is being planted rapidly, in order to take advantage of the good condition of the seed bed. If the crop can be brought above ground without the addition of irrigation water, the moisture situation will be relieved considerably.

Conditions on the dry land, as a whole, are much better than they have been for several years. On both dry land and irrigation, the acreage is being increased approximately 10 per cent above that of last year, which was below the five-year average. The amount being planted this year is still below the five-year average. This increase applies to both certified and non-certified plantings.

Growers, dealers, and others interested in the potato industry in Nebraska, are making plans to hold their position in the major markets by producing high quality table stock. The past season was one of the most successful, from the standpoint of marketing Red Triumph table potatoes, particularly in the markets of Chicago, St. Louis, Cincinnati, and as far east as New York. Every one interested in attempting to produce better quality, and the dealers, as a whole, are making plans to market the very best stocks to maintain the reputation established by the Nebraska product during 1939. (June 7).—MARX KOEHNKE.

NEW YORK

Throughout New York, the rainfall in May was much above normal. Planting was delayed by an average of nearly two weeks. This applied to Long Island as well as upstate. The results of late planting are likely to be especially serious to the muck growers in western New York where much of the planting was nearly a month late. Because

of the severe drought of last year, many of our seed stocks contain more internal browning and probably more leaf roll than normal. The demand for certified seed was, for most varieties, greater than the supply. Present indications show that the potato acreage in the state will be about the same as last year. (June 8).—E. V. HARDENBURG.

NORTH CAROLINA

The condition of our early Irish potato crop is better than the condition of a year ago and considerably better than the ten-year average. Digging is now in full swing although we are about a week later than normal. The commercial early crop is estimated at approximately 4,536,000 bushels which is about one per cent above last year's production despite a ten per cent reduction in this year's acreage. At the present time prices are approximately $1.15 to $1.25 per hundred pound sack. Washed potatoes bring about ten cents more than the unwashed. (June 13).—ROBERT SCHMIDT.

OHIO

There has been little change in the acreage of potatoes compared with 1939. Some early plantings along the Ohio River were frozen in March but replanted. The early potato crop was planted ten days to two weeks late and the crop will be proportionately late. Heavy rains have caused some damage to the early crop.

Wet weather in northern Ohio has delayed late plantings, especially in Northeastern Ohio where not more than two-thirds of the crop is in the ground and those planted have been somewhat damaged by water.

The acreage of early and medium-seasoned potatoes, Cobblers, Chippewas and Katahdins have increased with a proportionate decrease in the late planting. The total acreage for the state, although slightly increased will not be in excess of 1939 since the water damage will equal or exceed the slight increase. (June 14).—EARL B. TUSSING.

SOUTH CAROLINA

Potato digging and shipping were completed this week in South Carolina. Prices were fairly good during much of the season with growers obtaining approximately $2.00 a sack for U. S. No. 1's. Toward the end of the digging period prices fell off and the demand was not quite so strong.

Practically all the crop was shipped in sacks this year. This is an interesting example of a rather sudden change in market demand.

Three or four years ago it was a common belief that South Carolina potatoes had to be shipped in barrels because the market demanded it. It was said that sacks of potatoes brought much lower prices per bushel when compared with the same grade of potatoes in barrels.

In 1938 a number of growers in Charleston County packed their potatoes in sacks, mainly because they were cheaper and easier to handle than the time-honored, cumbersome 11-peck barrel. Last year still more growers used sacks and they found that their sacked potatoes brought better prices than the ones in barrels. This year it seems certain that the barrel has passed from the picture for good and that South Carolina's potato crop will henceforth be shipped in sacks until a better package is adopted.

Dry weather prevailed during the latter part of the growing season and caused decreased yields, but the quality of the crop as a whole was very good. Until the 10th of June, 3284 cars were shipped from this state and an undetermined quantity was moved by motor truck. Washers and dryers had been installed in several packing sheds but many growers did not use them because the tubers came out of the ground in very clean condition as a result of the dry weather.

The digging season was about ten days later than usual. This was a result of the cold weather early in the spring. There was little actual damage to the plants from frost, but the cool weather in April prevented the plants from making their normal rapid growth.

The White Rose variety was planted on a number of farms this spring and in several places excellent yields of large, oblong tubers were made. In other places the yields were rather poor and there were a lot of knobby potatoes. The tendency to form knobby tubers when alternating dry and wet weather is experienced seems to be one of the main faults of this variety. Under the same conditions Irish Cobblers and Katahdins formed normal tubers. Another trouble with the White Rose is the fact that it seems to be very susceptible to many diseases. Some of the commercial fields showed a high percentage of mosaic.

In variety tests at the South Carolina Truck Experiment Station one of the most promising new varieties is the Sequoia. This variety has been tested under a seedling number for several years at the station, and it has consistently produced high yields of No. 1 potatoes. During two of the three years it produced 25 per cent more potatoes than Irish Cobbler. Its main fault is that it matures ten days later than Irish Cobbler under South Carolina conditions, but there is a chance that it will be adopted by those growers who want a late crop to follow the earlier Bliss Triumphs and Irish Cobblers. Sebago also

produced good yields in variety tests, about the same as Chippewa, but it, too, is a late variety. Until potato breeders produce an earlier potato of the White Rose type, having smooth tubers and high yielding ability, it seems likely that growers in South Carolina will continue to cling to the old reliable Cobbler. (June 14).—MITCHELL JENKINS.

SOUTH DAKOTA

The potato crop is growing well in South Dakota, and the earlier plantings are about ready for cultivation. It is estimated that about 2000 acres will be certified with approximately 90 per cent being of the Bliss Triumph variety. The other varieties that will be entered for certification are Chippewas, Early Ohios, Irish Cobblers and Mesaba.

Field inspection will begin about the 15th of June and the annual potato tour will be held during the week of the 22d of July.

Certified growers reported a very good season last year with yields above 300 bushels per acre.

Seven new storage houses were built last fall. Construction of an additional house is being built for the new crop.

South Dakota seed has been checked very carefully for bacterial ring-rot and none has been found. (June 7).—JOHN NOONAN.

VERMONT

Because of excessive rains, potato planting was generally late and some acreage still remains to be planted.

Certified seed was cleaned up under brisk local demand during May. Most of our carload shipments went to Long Island points earlier in the spring.

There are prospects for a small certified seed acreage with only approximately 60 samples in the central test plot at Randolph Center. Since one sample may represent seed used by several growers, it is likely that ninety to one hundred growers may be represented.

Sales of table stock and some certified seed through chain store systems, with the Vermont Maple Sugar Cooperative acting as central agency, have increased. Many more potatoes could probably be handled in this way if the stock were available. Possibilities of establishing cooperative or community-backed warehouses are being considered in this connection. (June 14).—H. L. BAILEY.

WASHINGTON

The seed potato crop for the state of Washington has mostly been planted. In a few districts the seed potatoes are grown in the fall of the

year and ordinarily planting takes place some time between the 15th of June and the 15th of July.

The present indications are that the total acreage of certified seed potatoes in Washington will be about double that of last year. The increase will be planted to the White Rose variety. Climatic conditions at present are not very favorable for the potato crop. Cold rains have prevailed during most of the month of May causing considerable decay of seed pieces with consequent poor stands and slow growth. During the last few days, however, there has been a distinct change with much higher temperatures which will undoubtedly improve the condition. (June 10).—CHAS. D. GAINES.

POTATO TOURS

The 11th annual potato field day of the Empire State Potato Club will be held at Batavia on the 8th of August. Gilbert Prole, Master Farmer, and one of New York's farm leaders, will act as host.

Ohio State Potato Day will be held August 8 at the Virgil Royer Farm, Arcanum, Ohio. The program will include Vocational Agricultural Judging Contests, a short speaking program and machinery demonstrations.

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POTATO QUALITY. I. RELATION OF FERTILIZERS AND ROTATION SYSTEMS TO SPECIFIC GRAVITY AND COOKING QUALITY[1]

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One main reason for discrepancies in the results of cooking tests conducted by many investigators in the past as reported in the literature has undoubtedly been caused by the wide variation in mealiness within any one lot, regardless of treatment. There is often a greater difference in mealiness between the individual potatoes of any one lot than between the average tubers of any two treatments. When small numbers of tubers (usually 4 to 10) were selected at random from the field for the cooking sample, the tubers probably ranged from the most mealy to the least mealy of the lot. As a result when a small lot of tubers, probably no two alike in texture, were compared with another lot selected in a similar manner, it was not possible to detect any consistent differences in texture between the two samples as a whole. Several investigators have pointed out the high correlation between the specific gravity of a potato and its degree of mealiness. To more nearly standardize the procedure and to insure the selection of representative tubers for small cooking samples we now obtain the average specific gravity of the tubers of each treatment and then select our sample from tubers having the average specific gravity of that lot. Since it has been shown that specific gravity measurement can be used for narrowing the sampling range, probably many of the cooking tests on texture reported in the literature should be repeated.

We have recently suggested this method to growers, buyers, house-

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wives, potato stick manufacturers and others who may be interested in separating mealy from soggy or waxy potatoes as a practical low cost method for such separation. Sodium chloride (common table salt) solutions of various strengths are used for such separations. When separation is made on a large scale and the potatoes are to be stored or placed in containers and not consumed for some time it is better to rinse them in water and dry them before storing or packaging.

Methods

Each sample grown and selected in the field consisted of 50 to 100 tubers. The specific gravity of the sample was determined by placing the tubers in a series of sodium chloride solutions with differences between solutions of 0.004 in specific gravity. The specific gravity of each tuber was considered the same as that of the solution in which it first sank when started at the high end of the scale. Average specific gravity of each lot was determined by multiplying the number of tubers which sank in each solution by the specific gravity of that solution and then dividing the sum of these figures by the total number of tubers. Another solution was then made at the average specific gravity of the lot; and only tubers which had the same specific gravity, were selected from that lot for cooking tests.

Cooking Tests

Six tubers having the average specific gravity of the lot were selected for the cooking sample. Partially standardized boiling tests were used. The same size and kind of porcelain containers were used for all samples. The same amount of water, same time for boiling and uniform gas flames were employed. The potatoes were pared before boiling.

Results

The data in table 1 show that, although yields were markedly affected by increased increments of fertilizer, that the specific gravity and texture of the tubers were not altered until the 1500-pound-per-acre application was reached. The heaviest application decreased the average specific gravity and the mealiness of the cooked tubers as compared with the lower applications or those with no fertilizer. All cooked samples showed a slight amount of darkening at the stem end regardless of fertilizer treatment.

TABLE 1.—*Relation of rate of fertilizer application to specific gravity, mealiness and color of cooked tubers*

Rate per Acre	Average Specific Gravity	Yield Bushels per Acre	Smooth Rural Variety—Gravelly Loam Soil	
			Texture	Amount of Blackening
None	1.099	114	Mealy	Slight amount at stem end of all tubers.
500 lbs. 5-10-5	1.099	167	"	
1000 " 5-10-5	1.100	207	"	
1500 " 5-10-5	1.095	224	Slightly less mealy	No differences.

Similar results were obtained when the amount of potash only was varied as shown by the data in table 2.

TABLE 2.—*Relation of rate of potash application to specific gravity and cooking quality of potatoes*

1000 lbs. per Acre	Average Specific Gravity	Yield Bushels per Acre	Smooth Rural Variety—Gravelly Loam Soil	
			Texture	Amount Blackening
5-10-0	1.096	72	Mealy	Practically None.
5-10-5	1.096	167	"	
5-10-10	1.094	184	"	
5-10-15	1.090	198	Less "	All tubers black at stem end.
1333 lbs. per Acre			Green Mountain Variety; Sandy Loam Soil	
5-10-0	1.089	225	Mealy	Very slight amount in all samples. No differences.
5-10-5	1.089	313	"	
5-10-10	1.087	386	"	
5-10-15	1.085	374	Slightly less mealy	

With the Smooth Rural variety, 1000-pound-per-acre applications of 5-10-0 and 5-10-5 resulted in tubers of the same average specific gravity. Tubers of slightly lower average specific gravity were obtained with the 5-10-10 and still lower with the 5-10-15 application. Only at the latter application were tubers produced which were less mealy than those receiving the lighter applications of potash. It was also only at the heaviest potash application that tubers which blackened after cooking were produced.

On a sandy loam with the Green Mountain variety and with applications of fertilizer at the rate of 1333 pounds per acre the results concerning specific gravity and mealiness of tubers were practically the same as with the Smooth Rural on gravelly loam soil with 1000 pound per acre application. There were, however, no differences between treatments in degree of darkening after cooking, only a slight amount being detectable in each sample.

The data in table 3 show that in 1939 the time of application of the fertilizer had little influence on the average specific gravity and texture of the tubers (treatments 1, 5, 6 and 7).

TABLE 3.—*Relation of fertilizer application to specific gravity and texture of potatoes*

Time of Application and Amount per Acre	Smooth Rural Variety—gravelly loam	
	Average Specific Gravity	Texture
1. 1000 lbs. 5-10-5 at planting time	1.098	slightly less mealy
2. 1000 lbs. 5-10-5 at planting time + 500 lbs. hydrated lime	1.0977	—
3. 1000 lbs. 5-10-5 + amount of NPK in 12 T manure	1.092	soggy
4. 1000 lbs. 5-10-5 at planting time + 2% N. July 15 and 2% N Aug. 15	1.100	mealy
5. 500 lbs. 5-10-5 at planting time + 500 lbs. 5-10-5 July 15	1.101	—
6. 1000 lbs. 2½-10-5 at planting time + 2½% N July 15	1.100	mealy
7. 1000 lbs. 5-10-2½ at planting time + 2½% K July 15	1.098	—

The addition of lime to the fertilizer at planting time and the nitrogen-side-dressings also had little effect. Unquestionably the extreme drought of 1939 prevented a greater reaction of the plants to the above treatments. The outstanding treatment was number 3 which received in addition to the 1000 lbs. of 5-10-5 per acre, an amount of fertilizer equivalent to the nitrogen, phosphorus and potassium in a 12-ton-per-acre application of manure. This heavy application resulted in tubers with lower average specific gravity and tubers that were definitely soggy and yellowish-colored when cooked. Tubers of all other treatments were mealy to fairly mealy.

The effects of green manure preceding potatoes and of soil reaction on specific gravity, texture and color of potatoes are shown in the data of table 4.

TABLE 4—*Relation of soil reaction and green manure to specific gravity, texture and color of potatoes*

Soil Reaction (pH)	Average Specific Gravity	SMOOTH RURAL VARIETY—SILTY CLAY LOAM (Potatoes 6 successive yrs., 1 yr. corn + rye plowed under, then potatoes eighth year)	
		Texture Rating (1 to 6)	Blackening Rating (1 to 6)
4.92	1.083	3 mealy	5 one-half of surface dark
6.36	1.078	4-5 slightly mealy	3 one-third of surface dark
7.88	1.082	2 mealy	2 very little blackening
		Potatoes 8 successive years; no organic matter	
4.92	1.080	4-5 slightly mealy	6 about ½ of surface dark
6.36	1.076	6 slightly soggy	4 one-third of surface dark
7.88	1.085	1 mealy	1 very little blackening

Regardless of whether or not green manure crops had been plowed under preceding potatoes, the intermediate soil reaction plots (pH 6.36) produced tubers of lowest average specific gravity and least mealy texture. The mealiest tubers and those of the highest average specific gravity were grown in soils of pH 7.88 and to which no organic matter had been applied. There seems to be a correlation between soil reaction and degree of blackening; tubers grown in soil of low pH blackened to the greatest extent.

The relation of rotation systems to specific gravity and cooking quality is shown in the data of table 5.

Marked differences in yields of potatoes have been obtained during the past three years from the various rotation systems. It appeared probable that differences in cooking quality might also result. All potatoes, except those in rotation 10, received 1000 to 1200-pound-per-acre applications of 5-10-5 fertilizer. No manure was added to rotation 10 except in the fall of 1938 when a 12-ton-per-acre application was made.

With the Smooth Rural variety there were no marked differences in average specific gravity between any of the lots and consequently there were no noticeable differences in texture among the four lots tested, namely lots 2, 4, 8 and 9. All tubers were classed as mealy and all had a high average specific gravity. There were slight differences in degree of darkening after boiling, most, although not extensive,

TABLE 5—*Relation of rotation systems to specific gravity and cooking quality of potatoes*

Rotation	Smooth Rural-Gravelly Loam			Green Mountain-Sandy Loam		
	Average Specific Gravity	Texture	Amount of Blackening	Average Specific Gravity	Texture	Amount of Blackening
1. Potatoes every year, no manure, no rye cover	1.095	—	—	1.096	—	—
2. Potatoes every year, 12 T. manure, no rye cover	1.096	Mealy	Practically none	1.0958	—	—
3. Potatoes every year, 12 T. manure, rye cover	1.095	—	—	1.099	Mealy	Little
4. Potatoes every year, no manure, rye cover	1.091	Mealy	Some at stem end	1.0957	—	—
*5. 2 year rotation, potatoes after dry beans	1.096	—	—	1.099	—	—
6. 2 year rotation, potatoes after corn for green manure	1.096	—	—	1.1077	Mealy	Very little
7. 2 year rotation, potatoes after 1 yr. sod	+1.096	—	—	1.096	—	—
8. 5 year rotation, potatoes after 2 yr. sod	+1.092	Mealy	Some at stem end	1.095	—	—
*9. 5 year rotation, potatoes after dry beans	1.095	Mealy	Most darkening	1.093	Least Mealy	Very little
10. Potatoes every year, no fertilizer	—	—	—	1.1097	Most Mealy	None

*Soybeans for hay substituted for dry beans in the rotation with the Green Mountain Variety.
+Clover and timothy sod.

occurring in number 9, with a small amount at the stem ends of tubers of lots 4 and 8 and practically none in lot 2.

Greater differences in average specific gravity of the various lots of Green Mountain tubers grown in sandy loam soil were obtained than with the Smooth Rural variety grown in gravelly loam in another section of the state. The highest average specific gravity tubers were grown on plots where potatoes are grown every year and receive no fertilizer or cover crop and to which manure was applied only in the fall of 1938. The tubers also were the most mealy and exhibited no darkening after cooking. Lowest average specific gravity tubers were obtained from treatment 9, a 5-year rotation with potatoes following soybeans harvested for hay. These tubers also were the least mealy but showed only a trace of darkening after cooking.

Summary and Conclusions

1. Specific gravity measurement is a practical low cost method of separating mealy from less mealy or soggy potatoes on a commercial scale.

2. Fifteen hundred-pound-per-acre applications of 5-10-5 fertilizer produced tubers of lower specific gravity and tubers that were slightly less mealy than those of lower applications.

3. Applications of 1000 pounds of fertilizer per acre of 5-10-15 analysis resulted in Smooth Rural tubers of lower specific gravity and less mealiness than applications of fertilizer with less potash. Similar results were obtained with the Green Mountain variety receiving applications of 1333 pounds per acre.

4. Applications of 1000-pounds-per-acre of 5-10-5 fertilizer plus the amount of nitrogen, phosphorus and potassium in a 12-ton-per-acre application of manure resulted in tubers with lower specific gravity and much less mealy texture than those produced with lighter applications.

5. Soils of reaction of pH 6.36 produced tubers of lower specific gravity and less mealy texture than soils of higher and lower pH. The mealiest tubers and those of highest specific gravity were grown in soils of pH 7.88.

6. Of the 10 rotation systems, the highest specific gravity and most mealy tubers of the Green Mountain variety were grown on plots where potatoes are grown every year and receive no fertilizer or cover crop. Lowest specific gravity and least mealy tubers were obtained following soybeans harvested for hay.

THE EFFECT OF CHROMOSOME DOUBLING ON THE CROSSABILITY OF *SOLANUM CHACOENSE, S. JAMESII,* AND *S. BULBOCASTANUM* WITH *S. TUBEROSUM*[1]

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INTRODUCTION

One of the purposes of the experiments conducted by the junior author (Johnstone 1939) to induce polyploidy in potatoes was to study the effect of doubling the chromosomes of the lower-chromosome species on their crossability with *Solanum tuberosum,* which normally has forty-eight chromosomes in its somatic cells. Three wild species, *S. bulbocastanum, S. chacoense,* and *S. jamesii,* which ordinarily have twenty-four somatic chromosomes, have been doubled by colchicine treatment of the seed so that the 4n lines have the same number of chromosomes as *S. tuberosum.* A limited number of crosses of *S. tuberosum* with the 4n lines of the species just mentioned and the comparable diploids have been attempted. The results of these crosses are reported herein.

Stevenson and Clark (1937), Reddick (1939), and Clark (1939) have indicated that there are desirable, heritable characters appearing in *S. bulbocastanum, S. chacoense,* and *S. jamesii* which would be of practical value if they could be incorporated in our commercial varieties.

CONDITIONS OF THE EXPERIMENT

Some of the crosses with 2n plants of the wild species were attempted in the spring of 1938, but all involving 4n plants and the majority of the 2n crosses were tried in May and June of 1939.

All pollinations were performed in the potato breeding greenhouse at Ithaca. Although the thermostat control was set at 55°F. for night and 65°F. for day, the temperatures prevailing during most of the pollination period were considerably higher, sometimes reaching ninety during the day. The humidity was kept as high as possible by wetting down the benches, walls and floor several times each day. All plants were set in six-or seven-inch pots, on benches mostly but some

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of the *S. tuberosum* plants were in ground beds. Healthy plants were selected for both male and female parents. All plants of the wild species (both 2n and 4n) and all Katahdin, Earlaine, Ostragis, and Hindenburg were emasculated when used as female parents; Golden, Green Mountain, and the Rurals were not emasculated. Pollen was applied to each stigma on at least two different days and, in some cases, more. The tetraploid plants which were used had been selected from the progeny of colchicine-treated plants by chromosome counts in the root tips, size of the stomates, and size of pollen. In addition the size of the pollen

TABLE 1.—*Summary of crosses of S. tuberosum with 2n and 4n lines of S. bulbocastanum, S. chacoense and S. jamesii*

Cross	No. Clusters Pollinated	No. Seed-balls with Plump Seed	Total No. Plump Seed	Average No. Seed to a Ball
R. Rural x *S. bulbo.* 2n	5	0	0	—
R. Rural x *S. bulbo.* 4n	7	0	0	—
S. bulbo. 4n x Katahdin	2	1	1 (?)	1.0 (?)
Total *S. bulbo.* 2n crosses	5	0	0	—
Total *S. bulbo.* 4n crosses	9	1	1 (?)	1.0 (?)
Earlaine x *S. chacoense* 2n	2	0	0	—
Earlaine x *S. chacoense* 4n	2	2	95	47.5
Hindenburg x *S. chacoense* 2n	1	1	1	1.0
Katahdin x *S. chacoense* 2n	2	0	0	—
Katahdin x *S. chacoense* 4n	2	0	0	—
Ostragis x *S. chacoense* 2n	4	26	30 (approx.)	1.2 (approx.)
R. Rural x *S. chacoense* 2n	6	2	2	1.0
R. Rural x *S. chacoense* 4n	9	11	303	27.5
S. chacoense 2n x Earlaine	1	0	0	—
S. chacoense 4n x Earlaine	1	1	30	30.0
S. chacoense 2n x Ostragis	1	0	0	—
Total *S. chacoense* 2n crosses	17	29	33 (approx.)	1.2 (approx.)
Total *S. chacoense* 4n crosses	14	14	428	30.6
Earlaine x *S. jamesii* 4n	1	0	0	—
Golden x *S. jamesii* 4n	1	0	0	—
Gr. Mountain x *S. jamesii* 2n	1	0	0	—
Gr. Mountain x *S. jamesii* 4n	1	0	0	—
Katahdin x *S. jamesii* 2n	3	0	0	—
Katahdin x *S. jamesii* 4n	3	0	0	—
R. Rural x *S. jamesii* 2n	9	0	0	—
R. Rural x *S. jamesii* 4n	19	0	0	—
S. Rural x *S. jamesii* 2n	1	0	0	—
S. Rural x *S. jamesii* 4n	2	0	0	—
S. jamesii 2n x Earlaine	1	0	0	—
S. jamesii 4n x Earlaine	6	0	0	—
S. jamesii 2n x Katahdin	1	0	0	—
S. jamesii 4n x Katahdin	4	0	0	—
S. jamesii 2n x Ostragis	2	0	0	—
Total *S. jamesii* 2n crosses	18	0	0	—
Total *S. jamesii* 4n crosses	37	0	0	—

grains of the diploids and the tetraploids of the wild species was checked from time to time to be sure that only 2n or 4n pollen, respectively, was used.

In all three species, the percentage of viable pollen in diploids was higher than in tetraploids. In general, diploids contained more than 90 per cent viable pollen, whereas tetraploids of *S. bulbocastanum* and *S. jamesii* averaged approximately 60 per cent and those of *S. chacoense* seldom more than 10 per cent. The quantity of pollen in the anthers of the tetraploids was less than in those of the diploids.

The number of flowers pollinated in a cluster varied from two to ten but was usually more than five except when *S. jamesii* was used as the female. Ten of the *S. chacoense,* five of the *S. bulbocastanum,* and six of the *S. jamesii* 4n crosses were paired with similar 2n crosses, and are in every way comparable to them.

Results

The summarized results are presented in table 1. When *S. jamesii* was crossed with diploids or with tetraploids no seeds were obtained. From the crosses involving *S. bulbocastanum* only one small seed, which may or may not be viable, was produced. But with *S. chacoense* the results are strikingly different; a few seed were obtained in 2n crosses but many more were obtained in the 4n crosses. The average in a seedball was 1.2 for 2n and 30.6 for 4n. It is also interesting that the reciprocal crosses of Earlaine x *S. chacoense* 4n were successful.

Discussion

It seems evident, at least under the conditions prevailing when these pollinations were made, that doubling the chromosomes of *S. jamesii* does not increase its crossability with *S. tuberosum,* but that doubling does increase the crossability of *S. chacoense* with the same varieties of *S. tuberosum* which could not be crossed with *S. jamesii.* The results with *S. bulbocastanum* should be considered inconclusive, although, apparently they are similar to those with *S. jamesii.*

It is not within the scope of this paper to discuss at length or attempt to explain the opposing results obtained with *S. chacoense* and *S. jamesii* upon doubling of their chromosomes, but it should be pointed out that such results are not inconsistent with genetical and cytological facts and hypotheses. We have no method by which to tell whether

or not the difference in chromosome number is the barrier preventing crossing until the chromosome numbers are brought closer together and the cross actually attempted. Only one 4n plant of *S. chacoense* was in bloom when this work was done. Although it is believed that the increased effectiveness of the pollen from the tetraploid was caused by the chromosome doubling, there is the possibility that it was due to a gene mutation. New forms which might be gene mutations have been found in colchicine-treated diploid and tetraploid lines at Ithaca but no new forms were observed among the untreated plants. The diploid lines from which the tetraploids were produced have been inbred and seem quite homozygous.

Further evidence that doubling the chromosomes, in itself, affects self-fertility or inter-fertility has been given by the fact that whereas the authors have obtained no seed by selfing diploid *S. bulbocastanum*, approximately 25 seedballs with a good supply of seed have been produced by selfing 4n lines produced from those diploid lines. Also, although approximately 50 doubled plants of *S. tuberosum* (Golden, Russet Rural, and several seedlings) have been grown to maturity under conditions favorable for blooming, no flowers have been obtained. The checks, which were normal undoubled *S. tuberosum* plants, bloomed profusely.

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PERFORMANCE OF CLONAL STRAINS OF TRIUMPH POTATOES
V.
COMPARISON OF TRIUMPH STRAINS IN VARIOUS SOUTHERN STATES

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In the states along the Gulf of Mexico the Triumph has been the major variety for a number of years. In this region, potatoes are planted in midwinter when days are very short (11 hours) and cool (55° F.). As the season advances the days become longer and warmer. Stated in another way, the conditions are more favorable for carbohydrate storage during the early part of the growing season than late in the season.[2]

From 1930 to 1936 three or more of these strains were tested by various southern experiment stations and some private individuals.[3] All the seed potatoes used were from the dry-land seed plots at Alliance, Nebraska, and contained practically no virus or other seed-borne disease. During these years there was a great variation in conditions at any one place and there was an equally great range between locations in individual years.

These tests failed to uncover any practical consistent differences of any great magnitude. With late-fall or early-winter plantings made at the furthest south trial points, emergence was sometimes one to four days earlier with the early strains than with the late ones because of differences in completion of the rest period. Such differences were obliterated within a relatively few days after emergence. If allowed

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[1]Published with the approval of the Director as Paper No. 242. Journal Series, Nebraska Agricultural Experiment Station.

[2]H. O. Werner. The effect of controlled nitrogen supply with different temperatures and photoperiods upon the development of the potato plant. Nebr. Agr. Exp. Sta., Res. Bul. 75. Sept. 1934.

[3]The author very gratefully acknowledges the cooperation of the following individuals who were responsible for the conduct of the trial plats located outside of Nebraska: L. M. Ware, Alabama Polytechnic Institute, Auburn, Alabama; G. W. Ware, Fruit and Truck Branch Experiment Station, Hope, Arkansas; W. M. Fifield, Homestead, Florida; Dr. C. M. Tucker, Hastings, Florida; Dr. A. H. Eddins, Hastings, Florida. Arthur Frank, The Brown Company, Belle Glade, Florida; Dr. J. C. Miller, University of Louisiana, Baton Rouge, La.; J. P. Weston, Alexandria, Louisiana; W. L. Taylor, University of Missouri, Columbia, Missouri; R. M. Lott, Mississippi State College, State College, Miss.; Dr. John Bushnell, Experiment Station, Wooster, Ohio; W. H. Friend, Supt. Experiment Substation, Weslaco, Texas; and Clyde Tandy, Brownsville, Texas.

to remain in the field a long time (that is if not harvested early) the plants of the late strains remained green for a longer time than those of the early strains. This difference was not as great as in the northern plats.[4] In the southern plats these differences in vigor of vines of different strains were only slightly apparent before the customary harvest time. In some of these regions harvest occurs as early as 60 to 70 days after planting time, and in most places not later than 90 days after planting.

In the 1931 tests the late strains appeared to produce the highest yields, especially of U. S. No. 1 grade tubers as shown in table 1. The so called "very late" strain was frequently the heaviest producer. This higher yielding tendency of the late strains was especially apparent in 1931 at Alexandria which is located in north central Louisiana.

In the remaining years it was not possible to distinguish any tendencies for higher or lower yields by any of the strains or groups of strains. These results are given in table 2.

When compared in pairs, there was little difference in total yield in 1931 between the two earlier strains. The medium strain outyielded the earlier strains in 12 of the 19 tests. The production of the late strain was not appreciably greater than of the midseason and early strain and was most frequently less than of the very late strain. The very late strain was frequently more productive than any other strains. These differences were of essentially the same order with early and late harvesting. Apparently the early strains did not outyield the late ones at an early date. This is easily understood when one considers that in these southern plats tuberization began at much the same time in all strains and that the early-strain plants were less vigorous—that is somewhat senile—when the first harvest was made. Hence they could not have been expected to be more productive. This tendency for higher yields from the later strains was somewhat more pronounced when potatoes of U. S. No. 1 size were considered. In the 1931 tests the percentage of No. 1 size tubers was generally greatest with the late and least with the early strains. In these southern tests size was the only thing considered in establishing the grade reported. Therefore this difference in strains was caused by the greater size of the tubers

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[4]H. O. Werner. Performance of various clonal strains of Triumph potatoes: Comparisons under various conditions:—

I. Western Nebraska dry land. Am. Potato Jour. March 1940.
II. Western Nebraska irrigation. Am. Potato Jour. April 1940.
III. Central Nebraska. Am. Potato Jour. May 1940.
IV. Eastern Nebraska. Am. Potato Jour. June 1940.

TABLE 1.—*Trials of Triumph strains in* 1931 *in various southern states.*

Strain	Florida			Texas		Alabama		Miss.
	Hastings [1]		Belle Glade	Weslaco		Fairhope		State C'llege
	Jan. 14 Apr. 29 5-50	Jan. 14 May 4 5-50	Mar. 7 May 29 5-200	Feb. 11 Apr. 24 2-66	Feb. 11 May 2 2-66	Feb. 3 May 7 5-60	Feb. 3 June 3 5-60	Mar. 18 July 1 10-50
Total Yield in Bushels per Acre								
V. Early	142.2	151.5	164.5	256.6	306.6	126.6	162.3	66.3
Early	151.6	186.4	155.6	329.9	413.5	138.3	156.8	55.4
Medium	166.5	176.1	145.3	371.2	272.1	135.2	162.3	62.0
Late	170.5	170.7	148.0	303.6	296.9	138.0	156.7	56.4
V. Late	144.4	186.3	169.3	331.1	320.3	145.8	164.9	75.6
S. Dif.	31.2	34.6	1.8**			6.5**	8.5**	17.8**
U. S. No. 1 Grade—Bushels per Acre								
V. Early	52.8	73.8	103.6	237.4	276.3	76.1	120.7	54.6
Early	49.7	96.8	96.1	310.6	350.5	83.6	113.9	46.8
Medium	55.7	66.4	93.2	353.3	250.1	79.9	119.3	49.9
Late	84.4	86.6	98.3	281.8	277.6	98.2	128.8	47.4
V. Late	52.4	91.2	124.0	309.1	292.8	98.5	132.1	72.3
Percentage U. S. No. 1 Grade								
V. Early	37.1	48.7	63.0	92.5	90.1	60.1	74.4	82.4
Early	32.8	51.9	61.8	94.1	84.8	60.4	72.6	84.5
Medium	33.4	37.7	64.1	95.2	91.9	59.1	74.5	80.5
Late	49.5	50.7	66.4	92.8	93.5	71.2	82.2	84.0
V. Late	36.3	49.0	73.2	93.4	91.4	67.6	80.1	95.6
Percentage Yield of U. S. No. 1 Grade of Each Strain Was of Medium Strain								
V. Early	94.8	111.1	111.2	67.2	110.5	95.2	101.2	109.4
Early	89.2	145.8	103.1	87.9	140.1	104.6	95.5	93.8
Medium	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Late	151.5	130.4	105.5	87.5	117.1	122.9	108.0	95.0
V. Late	94.1	137.3	133.0	79.8	111.0	123.3	110.7	144.9

[1]Number of single row plats and number of hills per plot.
*F values significant at 5 per cent. **F significant at 1 per cent.

TABLE 1 (Continued).—*Trials of Triumph strains in* 1931 *in various southern states.*

[1]Number of single row plats and number of hills per plot.
*F values significant at 5 per cent. **F significant at 1 per cent.

TABLE 1 (Continued).—*Trials of Triumph strains in 1931 in various southern states.*

Strain	Louisiana								Arkansas		Missouri
	Houma		Baton Rouge		Alexandria				Hope		Orrick
	Feb. 10 May 5 5-40	Feb. 10 May 27 5-40	Feb. 14 May 11 5-40	Feb. 14 May 18 5-40	Feb. 19 May 18 1-200	Feb. 19 May 25 2-200	Feb. 19 June 1 2-200	Feb. 19 June 8 5-200	Mar. 11 June 11 4-33	Mar. 11 July 3 4-33	Apr. 17 July 24 10-50
Total Yield in Bushels per Acre											
V. Early	251.6		197.7	265.0	184	288	272	379	139.9	119.6	117.4
Early	265.2		174.0	256.0	204	264	307	430	133.2	121.3	92.2
Medium	254.8	317.2	194.0	257.0	216	300	348	405	143.2	124.0	116.5
Late	244.4	309.0	212.1	245.3	164	335	354	458	136.0	149.9	105.3
V. Late	263.4	289.7	220.8	237.5	216	330	396	475	151.6	134.7	115.6
S. Dif.			22.0*	45.0					23.8*	20.0**	30.8*
U. S. No. 1 Grade—Bushels per Acre											
V. Early	171.9		129.4	207.2	146	244	209	321	38.7	37.1	70.3
Early	194.1		106.2	201.9	156	225	265	375	41.7	37.6	52.3
Medium	190.7	260.0	122.5	197.1	168	253	304	341	35.8	37.3	73.0
Late	208.0	275.0	148.5	208.8	122	296	276	402	33.3	58.7	66.7
V. Late	234.0	231.9	160.4	188.8	184	299	342	421	43.3	47.4	74.6
Percentage U. S. No. 1 Grade											
V. Early	68.3		65.5	78.2	79.3	84.7	84.7	84.7	27.7	31.0	59.9
Early	73.2		61.0	78.9	76.5	85.2	86.3	87.2	31.3	31.0	56.7
Medium	74.8	82.0	63.1	76.7	77.8	84.3	87.4	84.2	25.0	30.1	62.7
Late	85.1	89.0	70.0	85.1	74.4	88.4	78.0	87.8	24.5	39.2	63.3
V. Late	88.8	80.0	72.6	79.5	85.2	90.6	86.4	88.6	28.6	35.2	64.5
Percentage Yield of U. S. No. 1 Grade of Each Strain Was of Medium Strain											
V. Early	90.1		105.6	105.6	86.9	96.4	68.8	94.1	108.1	99.5	96.3
Early	101.8		86.7	102.4	92.9	88.9	87.2	110.0	116.5	100.8	71.6
Medium	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Late	122.7	89.2	121.2	105.9	72.6	117.0	90.8	117.0	93.0	157.4	91.4
V. Late	109.1	105.8	130.9	95.8	109.5	118.2	112.5	123.5	120.9	127.1	102.2

TABLE 2.—*Trials of Triumph strains at various southern points during six different years.*

Strain	1930			1932				
	Louisiana			Texas		Miss.	Arkansas	
	Houma	Baton Rouge	Alex-andria	Wes-laco	Browns-ville	State College	Hope	
		Feb. 8-12		Jan. 22 May 5 4-154[1]	Jan. 27 May 9 24-50	Mar. 25 July 1 8-50	Mar. 21 June 9 4-50	Mar. 21 June 21 4-50
Total Yield—Bushels per Acre								
Early	273.8	108.3	135.8	109.4	62.8	30.7	180.7	173.9
Medium	260.4	185.7	119.5	86.9	49.7	33.9	177.5	172.2
Late	280.9	187.2	112.3	113.6	55.9	37.9	171.2	169.3
S. Dif.				23.7		13.0	13.3	10.5
Bushels per Acre—Marketable (No. 1 and No. 2)								
Early	223.2	112.7	98.0	76.2	53.4	30.7	168.9	162.8
Medium	214.6	100.0	89.5	55.6	39.7	38.9	168.0	160.6
Late	233.8	107.3	75.8	77.7	46.9	37.8	167.0	161.3
Per cent Marketable								
Early	81.6	56.7	72.2	69.7	85.0		92.8	93.6
Medium	82.4	53.8	74.8	63.9	79.8		94.3	93.2
Late	83.2	57.3	66.8	68.3	83.8		96.6	95.4
Percentage Yield of U. S. No. Grade of Each Strain was of Medium Strain								
Early	104.0	112.7	109.5	137.1	134.5	78.9	100.5	101.4
Medium	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Late	108.9	107.3	84.7	140.0	118.1	97.2	99.4	100.4

[1]First number indicates number of plats, second number represents number of hills per row, parenthetical number indicates number of rows per plat. In absence of parenthetical number all plats contained only single rows.
*F values significant at 5 per cent level, **F values significant at 1 per cent level.
[2]Severe frost damage early in season, dry weather at LaCrosse late in season.
[3]Rest period not yet completed, emergence was slow and stands, especially with late strains, were poor.

TABLE 2 (Continued).—*Trials of Triumph strains of various southern points during six different years.*

[1]Rest period not yet completed, emergence was slow and stands, especially with late strains, were poor.

TABLE 2 (Continued).—*Trials of Triumph strains of various southern points during six different years.*

Strain	1933 Louisiana Houma	1933 Louisiana Baton Rouge		1934 Louisiana Baton Rouge	1934-35 Florida West[2] Tocoi	1934-35 Florida La[2] Crosse	1934-35 Florida Home-[3] stead	1936 Ohio Mari-etta
	May 10 4(5)250	May 11 2(5)250	May 26 4(5)250	May 28 5-40	Jan. 23 Apr. 30 7-50	Feb. 1 May 14 5-50	Nov. 23 Apr. 2 3(4)200	Apr. 3 July 28
Total Yield—Bushels per Acre								
V. Early	102.2	147.9	174.4	132	223	97.7	77	
Early	99.8	123.6	177.2	168	198	111.2	52	94.4
Medium	100.1	129.2	149.5	157	244	116.0	31	
Late	106.9	132.7	168.1	159	164	59.6	62	123.8
S. Dif.		80.0*	78.0		36.90**	41.0**	17.6	
Bushels per Acre—Marketable (No. 1 and No. 2)								
V. Early	81.2	134.0	167.1	119	223	79.7	68	
Early	90.8	102.3	165.2	151	198	111.2	45	59.3
Medium	94.1	117.3	139.4	137	244	116.0	23	
Late	97.3	118.5	160.4	146	164	59.6	55	88.7
Per cent Marketable								
V. Early	89.2	90.7	95.9	90.0			88	
Early	91.0	90.9	93.2	89.9			82	62
Medium	88.8	90.8	93.2	87.2			74	
Late	91.0	89.4	95.4	92.0			89	71.6
Percentage Yield of U. S. No. 1 Grade of Each Strain was of Medium Strain								
V. Early	86.3	114.2	119.9	86.9	91.4	68.7	295.7	
Early	96.5	87.2	118.5	110.2	81.1	95.9	195.7	
Medium	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
Late	103.4	101.0	115.1	106.6	67.2	51.4	239.1	

[1]First number indicates number of plats, second number represents number of hills per row, parenthetical number indicates number of rows per plat. In absence of parenthetical number all plats contained only single rows.

*F values significant at 5 per cent level, **F values significant at 1 per cent level.

[2]Severe frost damage early in season, dry weather at LaCrosse late in season.

[3]Rest period not yet completed, emergence was slow and stands, especially with late strains, were poor.

from the late strains. Differences of this kind were less apparent in other years when tests were conducted.

These data indicate that because of the great variability in seasonal conditions it is difficult to state that any strain is better than another for either any specific or very large region in the south. In most instances the difference in yield was very small and not always in the same direction. The general tendency of late strains to remain green slightly longer (but not so much longer than in the north) and to produce a higher percentage of large tubers than the earlier strains seems to be the most specific observation that may be made. Other aspects need to be considered. It is a commonly accepted fact that tubers from the late strains are very frequently rougher and more elongated and therefore of less desirable type than those of the early strains. Consequently when such tubers are compared with early strains they do not present so good a market appearance. Being slightly more immature at harvest they require more careful handling. Southern environmental conditions by inducing very early tuber formation, tend to reduce or obliterate some of the differences in strains that were very apparent in the North.[4] An analysis of the performance of these strains under controlled environmental conditions is being presented in the next paper in this series (Being published in Jour. Agr. Res.).

General Conclusions Concerning Adaptation of Triumph Strains

Where potatoes are grown as a late crop on dry land the late strains appeared to produce the highest yields in most of the years and seemed less likely to produce scabby tubers; however, they produced somewhat rougher tubers and were least productive in dry years. The earliest strains lacked in productivity in the best years and tubers were quite scabby. Midseason strains appeared to be most desirable because of being reasonably satisfactory each year.

With irrigation in western Nebraska the earliest strain was desirable if planted early or planted very late but seemed hazardous for midseason planting because of the possibility of much scab infection. If used, plants should be spaced close together. The medium strain appeared most generally suitable. The later strains appeared to have the least scab even if planted early. However, the large vine growth, large tuber size, and inferior tuber type render late strains of dubious merit.

In eastern and central Nebraska with or without irrigation, the

earliest strain was the only one that may be considered desirable and it seldom was equal to the other early varieties such as Warba or Irish Cobbler.

In the southern states yields were slightly the greatest with the late strains but because of the somewhat superior tuber type, generally characteristic of the earlier strains, the latter were frequently most desirable. The very early strains did not seem so suitable for general use in the south as the second early or midseason strains. In the south the difference between strains—with regard to time of tuberization, etc.—was very much less than when the same strains were grown in the north.

SECTIONAL NOTES

CALIFORNIA

The Shafter Deal is now entirely finished. The total shipments including the 30th of June were 11,746 cars from Kern County. These consisted of 530 cars from the Arvin District; 2960, Edison; 1145, Lerdo/Saco; 4635, Shafter; and 2476 cars from the Wasco District. These shipments compare with those of last year at the same date which totaled 11,933; and in 1938, 9261.

The prices on Shafter potatoes ranged from $1.40/1.50 on April 12th; $1.50/1.55, April 16th; $1.25/1.30, April 23d; $1.20/1.30, April 25th; $1.15/1.25, May 4th; $1.75/1.90, May 29th; $1.10/1.20, June 5th; $.95/1.05. June 6th; $1.30/1.40, June 11th; $1.00/1.05, June 18th; in other words, it was quite a changeable market, with high and low prices.

The yields were much lighter than ever before, principally due both to disease and the fact that a considerable acreage was condemned because of net necrosis. The Stockton District is now beginning to ship. The acreage is somewhat less than last season and according to present indications the yields also promise to be lighter than they were last year.

The opening prices in Stockton were $1.50 per cwt. for the US No. 1. (July 8).—E. Marx.

There is little to offer regarding the potato work at present in this county other than in our mountain area we have approximately two thousand acres planted, some of which will be harvested the latter part of this month and the remainder during August, September, and October. We are also developing another area in an adjacent county which will be marketed through this county. This is known as the Cuyama Valley. There are about eight hundred acres in the Cuyama Valley this year which will be harvested probably during the latter part of August.

Our potato industry has now spread so that we have four distinct areas: Edison area harvesting in March; Shafter area, harvesting the latter part of April; Tehachapi or mountain area harvesting during the latter part of July; and the New Cuyama Valley area which will probably begin harvesting in August.

The indications at present show that the 1941 acreages will be greater than those of 1940. Many potato growers have already contracted their seed for 1941, others are contracting at the present time.

Ring rot still remains as our principal problem, and, of course, an enormous amount of work is being done by the University of California on this particular problem. Some experimental data have already been obtained in this county which will be released by the authorities who conducted this experiment. I would suggest that you write to J. B. Kendricks, Plant Pathologist, College of Agriculture, Davis, California, for a report of their findings. I have a copy of the material on my desk at this time, and it certainly does open the eyes of some of us with reference to the ease of dissemination of this disease. (July 8).—M. A. LINDSAY.

FLORIDA

The abnormally cold weather at Hastings during December, January, and February was unfavorable for the germination and early growth of potatoes; consequently, stands were not established in the early-planted fields until the first week in March. Growing conditions were exceptionally favorable for potatoes during March, April, and May, and the vines remained green longer than usual, thus making it necessary to dig the crop three weeks later than usual. An average yield of 200 bushels per acre in 1940 was the heaviest ever produced in the Hastings section, and was about double the average yield of 110 bushels per acre obtained during the 11 preceding years (1929-'39). The

total acreage in the Hastings section was 1,700 acres less than last year's acreage, but production was 60 per cent greater than in 1939. Our shipments by train, boat, and truck for 1940 were estimated at 4,500 cars.

In 1940, growers continued to abandon the growing of the Spaulding Rose variety and planted 80 per cent of the total acreage in Katahdin and 10 per cent in Bliss, Earlaine, Sebago, and White Rose.

Prices received for potatoes during our 1940 season are much lower than those of 1939 as they were depressed very soon after the shipping season started by shipments of immature stock which was in poor condition on arrival at the principal market centers. Best prices were received for matured stock during the latter part of the shipping season.

The season was unfavorable for the development of potato diseases, particularly late blight and brown rot. The planting stock consisted of 92 per cent certified seed and 8 per cent selected seed. The seed contained only a trace of the usual seed-borne diseases with the exception of ring rot which was present in all of the selected seed and in two small lots of certified seed. The loss attributed to all diseases was only 6 per cent, which was the lowest recorded loss during the 9-year period, 1932-40. (July 10).—A. H. EDDINS.

INDIANA

Timely rains, cool weather, and good general growing conditions give promise to one of the best crops of early-maturing potatoes that we have encountered in our state for many years. Prospects are really good for a high yield of good quality potatoes. Most of our growers are using Cobblers for the main crop, with Katahdin as a second choice, followed by Chippewa and a few Rurals. Late potatoes look well, with a few growers making their last planting this week and others still looking around for some seed.

The Colorado potato beetles were very numerous this spring, averaging about 1½ adult beetles per plant. Flea beetles and leafhoppers were also quite numerous and only those fields that were thoroughly sprayed or dusted with timely applications show little or no damage. More insecticides were purchased and used this year than ever before. (July 5).—W. B. WARD.

MAINE

Rainfall has been the heaviest on record for the month of June since 1909 with one exception, namely 1932. The rainfall this month has

been 7½ inches and the normal is about 3 inches. In 1932 we had 11 inches which is an all-time record. The weather is showing signs of changing now and we hope that July will be more favorable.

Potatoes have withstood the heavy rains remarkably well. Considerable erosion has occurred,—much more than usual. Many fields have areas or spots that are lost, but taking the crop as a whole it is looking well at date of writing,—the 6th of July. It is probably a week or ten days later than the average crop but the stand is excellent. There seem to be less missing hills than has been the case for many years.

The acreages entered for certification with the State Department of Agriculture are as follows, in round figures:

Green Mountains	12,000	Spaulding Rose	200
Irish Cobblers	10,700	Bliss	300
Katahdin	9,800	Warba	27
Chippewa	4,800	Mesaba	11
Russet	300	Early Rose	4
Earlaine No. 2	900	Pontiac	4
Sebago	900	All Others	32½
Houma	200		

This gives a total entry of 40,304½ acres which is an all-time high. It is interesting to note the major increases: the Katahdin variety about 3,000 acres; Chippewas approximately 2,000; Earlaine 300; and the Sebago from none in 1939 to 900 this year. The decreases were chiefly in the Spaulding Rose and Warba varieties. The Spaulding Rose variety has declined from 504 acres to 220 acres, and Warbas from 207 acres to 27 acres.

The Farm Bureau sponsored a Roguing School at Aroostook Farm on the 5th of July at which instruction was given in roguing diseased plants. This is indicative of the real interest developed.

Growers are starting their spraying applications. Considerable change has taken place in the equipment used during the past few seasons. Any new equipment purchased now is usually of the type that is readily mountable on tractors although, of course, the predominating type is the horsedrawn traction sprayer. A great improvement has taken place in the quality and kind of equipment. (July 6).—FRANK W. HUSSEY.

MICHIGAN

The acreage of both certified and table stock potatoes planted in Michigan is about the same as last year.

Excessive rains that prevailed during the early part of the season

delayed plantings to some extent. Some early plantings on low land, where soil was water-logged, resulted in poor stands. The plantings this year were generally ten days later than usual. The potatoes in the later-planted fields are now coming up and show good stands with plenty of vigor. A slightly increased use of commercial fertilizer was observed this year, probably because of reduced fertilizer costs.

Growing conditions have been very favorable in Michigan for potatoes to date. (July 10).—H. A. REILEY.

NEBRASKA

Although the growers in western Nebraska, where most of the commercial crop is grown, started planting about the 25th of May, a week to ten days earlier than usual, planting was still not completed by the 1st of July. Of course. the major part of the crop was planted by the 20th of June. Planting conditions were, on the whole, quite satisfactory. There was good moisture in seed beds, from early spring rains, and the temperatures were not excessive, which is a hazard in many years. Good stands appear to be the rule.

During the month of June, there was practically no rainfall. This situation will not become serious until the plants begin to draw on the moisture in seed beds, during the next two or three weeks. This is most serious with the growers under ditch irrigation, where their storage water is extremely short. They had hoped for an occasional rain to get the plants established, and to avoid the necessity of tapping the water supply early.

Harvesting operations will be under way very soon in the Kearney-Gibbon, and the central Nebraska area adjacent to Burwell and Arcadia. The crops in that area were in good condition about a week ago. The latter is a new potato-producing area, and has produced more potatoes than were produced during the first season, that of 1939. Growers are attempting to move cautiously in all respects, taking advantage of all the information they can obtain for good production, harvesting methods, orderly marketing, etc.

Final reports on seed potato certification are being summarized at this time and some increase may be seen over the acreage entered for certification in 1939. The same increase is being observed in commercial, or non-certified acreage. This will probably be between 5 and 10 per cent but it is still under the average for past seasons.

Field inspection will begin this coming week on the earlier-planted acreages that have been entered for certification. (July 7).—MARX KOEHNKE.

NORTH CAROLINA

The early potato harvest season in North Carolina is practically completed. Our shipments through the 5th of July showed a total of 7073 cars as compared with 6871 cars last season. The shippers estimate four to five hundred additional cars this season. Our season has been later than usual because of the cold winter and spring but the planting and growing conditions have been generally good. The principal variety shipped was the Cobbler. Limited quantities of Chippewa, Katahdin, and Bliss Triumph were available.

North Carolina truck shipments were heavier than last season. Shippers estimate that 25 to 30 per cent of the total North Carolina potato movement was by truck. The prices ranged from $1.90 per sack the first week to a low of $1.00 per sack late in the season. It is estimated that from ten to fifteen per cent of the potatoes shipped during the 1940 season were washed. Prices were about ten cents higher for washed stock. (July 9),—ROBERT SCHMIDT.

OREGON

The Klamath potato crop seems to be from 10 days to two weeks further advanced than normal. The acreage seems to be about the same as last year and the stands are average or better. Market conditions indicate that harvesting for immediate sale will start a little earlier than normal, possibly shortly after the 1st of August. However, the quantity moving to market during August will be small.

There is an increased interest in the production of certified seed with more than average entries to date. The first field inspection will take place next week. Interest has centered around White Rose and Russets for certification. The total acreage may reach 1,500 for the district. To date the crop seems to be quite free from disease of all kinds.

The old crop was cleaned up by the 1st of July with a total of 7,753 cars being shipped. (July 9).—C. A. HENDERSON.

RHODE ISLAND

The potato crop is in excellent shape. The spring was a little late but the crop is now generally as far along as in the average season. There has been ample moisture. The acreage planted is approximately the same as last year or slightly more. Green Mountains constitute the bulk

of the acreage, with Cobblers next, whereas an increasing acreage of Chippewas is being grown each year. There are also a few acres of Sebagos. (July 5).—T. E. ODLAND.

SOUTH DAKOTA

Potatoes are off to a good start in South Dakota. The condition in most of the fields is excellent, with the Cobblers now in full bloom and the Bliss just starting to blossom. Earl P. Barrios of Donaldsonville, Louisiana is assisting with the field inspection. More than 1800 acres have been entered for certification.

Growers are doing more dusting this year. Four new dusters have been purchased.

Some complaints concerning blister beetles have been reported from Clark County where the largest acreage of certified potatoes are planted this year.

Moisture conditions are satisfactory at present, but one more rain will insure the crop. (July 8).—JOHN NOONAN.

WASHINGTON

Have just spent ten days in our certified White Rose seed potato section. Although our acreage is almost doubled, we have had the driest and hottest June that has been experienced for a number of years. Although irrigation systems are being set up on a number of farms, in many cases it will be too late to serve the desired purpose. Considerable damage in production and quality is already evident.

We look for a reduced yield ranging between 30 and 40 per cent on an acre basis below last year's crop. About 10 per cent of the fields have already been rejected because of excessive amounts of disease or other unfavorable conditions. We have been diligently searching for the presence of bacterial ring rot caused by *Phytomonas sepedonica*. However to date we have been unsuccessful in finding a single trace in our White Rose seed stocks. (July 10).—CHAS. D. GAINES.

ERRATA

In the June issue, in the article by Julian C. Miller *et al*, on page 141, figure 1 should be reversed.

The volume number of the June issue, 6, was omitted from the front cover.

NATIONAL POTATO BREEDERS' CONFERENCE AT BATON ROGUE, LOUISIANA AND FAIRHOPE, ALABAMA

E. L. LeClerg[1]

Bureau of Plant Industry, United States Department of Agriculture, Washington, D. C.

The biennial meeting of the National Potato Breeders' Conference was held from the 15th to the 18th of April 1940 in Louisiana and Alabama. Thirty-nine people representing eleven states and Cuba were in attendance.

The morning of the first day was spent in-doors where the group was welcomed by Dean J. G. Lee, Dean of the College of Agriculture of Louisiana State University. He pointed out some of the problems confronting agriculture in Louisiana and emphasized that the experiment station worker should not lose sight of the application of his researches to the needs of the farmer. Julian C. Miller of the Louisiana Agricultural Experiment Station discussed the Louisiana potato breeding program up to the inception of the federal breeding project for the southern states. He stated that he had been making crosses between most of the commercial varieties in order to find combinations that would yield high numbers of desirable individuals. Experiments had been conducted for resistance to scab, mild and rugose mosaics, and spindle tuber. Following this, E. L. LeClerg, of the United States Department of Agriculture, stationed at Baton Rouge, discussed potato production and breeding in the southern states. The federal potato breeding program for the South was outlined, in which it was pointed out that work would be conducted for resistance to scab, mild and rugose mosaics and early blight. Since this program is regional in its respect, much emphasis will be placed on some of the fundamental problems of potato breeding and pathology. A study of physiologic races of *Alternaria solani* will be made as it concerns the entire south in relation to resistance or susceptibility of varieties. Susceptibility of wild hosts will be investigated in a study to determine the source of early infection in the spring.

The first afternoon was spent in the field inspecting the potato work being conducted at Baton Rouge. During the afternoon F. A. Krantz, of the Minnesota Agricultural Experiment Station, discussed the phenotypes of most of the color genes and some of their interactions. Some of his material had been planted at Baton Rouge and could be examined by those interested. He plans to use these color genes in the study of quantitative inheritance, such as scab resistance.

[1]Pathologist, Division of Fruit and Vegetable Crops and Diseases.

Later, E. L. LeClerg discussed a field exhibit of some of the more commonly used breeding parents. The characteristics, such as disease resistance, color factors, yielding ability, and earliness, were pointed out for each variety of seedling. In another set of plots Julian C. Miller pointed out the better growth produced by northern-grown seed as compared with southern-grown stock. Past investigations have shown that northern-grown seed of most varieties outyields seed produced in the south.

The second morning was spent inspecting the breeding work being carried on by the Department of Horticultural Research of the Louisiana Agricultural Experiment Station with strawberries, onions, tomatoes, and sweet potatoes. The people in attendance were given a sample of the new strawberry seedling that is soon to be released by the investigators at the Station.

The potato work being conducted in cooperation with the Department of Horticulture of Southwestern Louisiana Institute at Lafayette, Louisiana, was inspected on Tuesday afternoon. Considerable interest was exhibited in the federal tests dealing with the effect of different amounts of leaf roll and spindle tuber on yield and the effect of time of roguing on yield.

A round-table discussion was held at the hotel at Lafayette, Louisiana, on the 16th of May. J. R. Livermore of Cornell University stated that potatoes with better quality and leafhopper resistance were needed for western New York. F. A. Krantz of Minnesota discussed some of the fundamental genetics of the potato and emphasized the selection of self-fertile lines. G. H. Rieman of Wisconsin stated that their work was concerned primarily with scab. An extensive breeding and testing program is in progress to develop varieties resistant to scab under Wisconsin conditions.

According to H. O. Werner of Nebraska, varieties with resistance to heat are needed for the western part of the state. In greenhouse studies it was determined that the variety Triumph produced the greatest number of flowers under continuous light conditions. C. H. Metzgar of Colorado, K. C. Westover of West Virginia, and J. J. Bird of Tennessee stated that they are engaged only in testing seedlings for adaptability to their conditions. Reiner Bonde of Maine is testing for resistance to bacterial ring rot and late blight.

At Houma, Louisiana, the third day, the group examined the field work dealing with scab resistance, adaptation plots, variety test, and the effect of various sizes and numbers of skips on yield. This last named test and the one on roguing as influencing yield at Lafayette incited considerable interest. These are very important factors in con-

ducting yield tests and deserve more investigation. The night was spent in New Orleans where many of the group took advantage of the opportunity to visit the "French Quarters."

During the last morning, the group drove to the Alabama Gulf Coast Experiment Station at Fairhope, Alabama. It was planned to inspect the potato work being conducted by H. L. Darling at the station and to have field discussions of several important potato diseases. However, because of excessive rainfall it was impossible to get into the plots.

Several members of the group expressed the idea that at the next meeting of this group arrangements should be made for a round-table discussion of breeding methods and problems. A number of people indicated that these biennial conferences were worthwhile as they gave a chance for informal exchange of ideas and better acquaintance among the different workers.

POTATO INSPECTION CONFERENCE

Seed potato inspection officials of the northeast met at Cranbury, New Jersey, on the 19th of June. Those attending were:

W. H. Martin, P. B. Mott, John Campbell, O. G. Bowen, and B. H. Davis from New Jersey; R. A. Jehle and W. F. Jefferson from Maryland; H. L. Bailey from Vermont; O. C. Boyd from Massachusetts; K. W. Lauer and Ralph S. Styer from Pennsylvania; A. D. Stuart from North Carolina; K. H. Fernow, Ross Watson, Spencer Duncan, and Ray Huey from New York; E. L. Newdick and J. L. Scribner from Maine; A. E. Mercker from the U. S. Department of Agriculture; and John Tucker from Canada. An interesting series of demonstration plantings was observed. Of special interest was a field-run planting of stock affected with yellow dwarf, about 20 per cent showing as a result of one year's exposure to infection. All stages of the disease were present. Specimens of haywire also attracted attention. Plantings of tubers showing net necrosis and stem-end browning demonstrated the relationship between the former disease and leaf-roll and the possibility of distinguishing between these troubles by examination of the tubers. Tubers from purple-top affected plants, for the most part, had failed to sprout, although the undecayed seed pieces were usually found. In some cases plants were produced, the stems usually being small and weak, suggesting a hair-sprout condition. Estimates by those present of the percentage of spindle tuber and leaf-roll in experimental plots proved highly accurate.

K. H. Fernow.

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POTATO DIGGER ADJUSTMENT IN RELATION TO TUBER BRUISING[1]

E. V. HARDENBURG AND C. N. TURNER[2]

Cornell University, Ithaca, N. Y.

Mechanical injury is known to be one of the most serious and common defects found on potatoes sold in our markets. The senior author (3) recently reported that nearly 40 per cent of all damage found on 515 retail store samples in the Cleveland and Rochester markets during the 1936-1937 marketing season was caused by bruising. A considerable portion of this bruising was caused by the digger. Hastings (4) reported that a survey behind fifty diggers in 1930 showed an average of 38 per cent of the tubers more or less bruised by the digger. Werner (6) in a similar survey made the same year on 47 farms found an average of about 20 per cent of digger-injured tubers. Similarly, Schrumpf (5) in 1933 reported an average of about 17 per cent of tubers bruised by the digger in Maine. Hardenburg (1) reported an average of 9 per cent of bruised tubers found behind the diggers on 238 New York farms in 1931 and 1932. The significance of these results prompted a series of potato digger field demonstrations designed to show the grower how and to what extent bruising can be reduced by proper adjustment and operation of his digger. This is a report of the results obtained during the years 1936, 1937, and 1939 with 61 diggers on 32 different farms in 10 New York counties. The work was done jointly by the Departments of Vegetable Crops and Agricul-

[1]Published as Paper No. 215, Department of Vegetable Crops, Cornell University, Ithaca, N. Y.

[2]Extension Professor of Agricultural Engineering.

tural Engineering of the New York State College of Agriculture. The demonstrations served three purposes: (1) to emphasize the seriousness of digger bruising, (2) to illustrate how bruising can be largely eliminated by proper adjustment and operation of the machine, and (3) that these results can be obtained without cost to the grower.

Seven factors were found to be of considerable influence in relation to the incidence of bruising. Each of these factors is discussed in this report and the summarized results given in table 1. All percentages given in the table are based on a count of 100 tubers examined for each operation.

Depth of Digger Point

The amount of soil carried on the digger chain as determined by the depth of setting the point was found to influence the percentage of bruised tubers in each of 5 paired comparisons. With the point set shallow as already adjusted by the grower, 10.8 per cent of the tubers were bruised. By lowering the adjustment lever one or two notches to set the point deeper, the average per cent of bruising was reduced to 4.2 per cent, a difference of 6.6 per cent with odds of significance of 16 to 1. This is in accordance with results previously reported by Hardenburg (1) for 72 New York farms in 1932. On those farms, bruising averaged 8.3 per cent less where 75 per cent or more of the apron was covered with soil than where 25 per cent or less was covered.

Agitation

Most diggers, when purchased have been equipped with agitator sprockets under the elevator chain. Growers too often fail to replace these with rollers when the soil is dry and very little goes over the apron. The most appropriate place for agitation when needed is under the front elevator. Furthermore, it would seem desirable if more diggers were equipped with a lever to allow the operator to vary the amount of agitation in accordance with the variation in soil conditions in different parts of the same field. In the four-paired comparisons made in this study under dry soil conditions, replacement of the agitator sprockets with rollers reduced the average per cent of bruised tubers from 4.5 to 0.75, a difference

of 3.75 per cent. Although there was a reduction in bruising in every instance, the difference was sometimes small with the result that the odds of significance are only 15 to 1.

Speed of Apron

It is fairly obvious in operating the digger that as the speed of the chain increases, less soil will be carried, the tubers will be thrown against the chain-rods and more bruising will result. It was shown by the senior author (2) in an earlier report that with an extension-elevator type of digger, bruising increased from 4.25 per cent when the chain was operated at low speed (7.2 R.P.M.) to 16.0 per cent at high speed (19.2 R.P.M.). In the field demonstrations where power take-off equipment was available, it was possible to compare low, intermediate, and high speed of apron as related to the incidence of bruising. Bruising increased directly with apron speed and averaged about 2, 8 and 15 per cent respectively as shown in table 1. The differences in bruising counts between low and intermediate speed and between intermediate and high speed were nearly the same, averaging about 6 per cent. The difference between high and low speed in 7 direct comparisons averaged 13.6 per cent bruising, the odds of significance being relatively high.

Apron Tension

A loose elevator chain on the continuous apron type of digger is subject to whipping at the rear end. This frequently is the cause of unnecessary tuber injury. In these field tests with 10 diggers, it was possible to remove 3 to 5 chain rods and thereby eliminate the whip by tightening the chain. In eight of these ten comparisons, tightening the chain resulted in less bruising, the average difference being 4.2 per cent and fairly significant.

Rear Chain Drive

Most of the elevator diggers now in use are designed for a separate or rear attachment apron. When such diggers are readjusted to provide a continuous apron, it is impossible without a change of drive sprockets to operate satisfactorily. Without an outside rear drive-chain, all of the draft is on the one main drive

TABLE 1.—*Potato digger adjustment in relation to tuber bruising (Based on 61 diggers—32 farms in 10 New York Counties 1936-1939)*

Factor Related to Bruising	No. of Farms	No. of Paired Comparisons	No. of Tubers Bruised (Per cent)	Ave. Difference (Per cent)	Odds of Significance
Depth of Digger Point	4	5			
Shallow			10.8		
Deep			4.2	6.60	16:1
Agitation	4	4			
On			4.5		
Off			0.75	3.75	15:1
Speed of Apron					
Intermediate	9	10	7.6		
Low			2.3	5.30	81:1
High	7	7	14.0		
Intermediate			7.8	6.20	1428:1
High	7	7	15.0		
Low			1.4	13.60	434:1
Apron Tension	8	10			
Loose			7.4		
Tight			3.2	4.20	37:1
Rear Chain Drive	3	3			
Off			4.33		
On			1.33	3.00	16:1
Shaker-bar Padding	9	9			
Not Padded			9.55		
Padded			4.22	5.33	555:1
Type of Digger					
Extension Apron	9	9	13.0		
Continuous Apron			4.33	8.66	69:1
Extension Apron	4	5	11.20		
Shaker-bar			8.60	2.60	7:1
Shaker-bar	10	13	10.46		
Continuous Apron			1.92	8.54	1428:1

sprocket which results in undue wear of the sprocket teeth and of the chain and usually too much chain whip at the rear of the digger. By use of the outside rear drive-chain, this whip is eliminated and less bruising results. Bruising was reduced by an average of 3.0 per cent when this adjustment was made on three continuous apron diggers as shown in the table.

Shaker-bar Padding

One of the oldest types of digger still widely used and still sold is the one with a rear attachment consisting of shaker-bars. Considerable bruising occurs when tubers drop from the front elevator onto these iron rods. More than one-half of this bruising can be eliminated by rubber padding at very little cost. This was demonstrated by padding nine diggers of this type with an 18-inch length of old auto tire over the horizontal bar and with a 12-inch length of one-half inch garden hose on each of the four vine-diverting tines. Bruising was reduced in every instance, the average reduction being 5.33 per cent and highly significant, as shown in table 1.

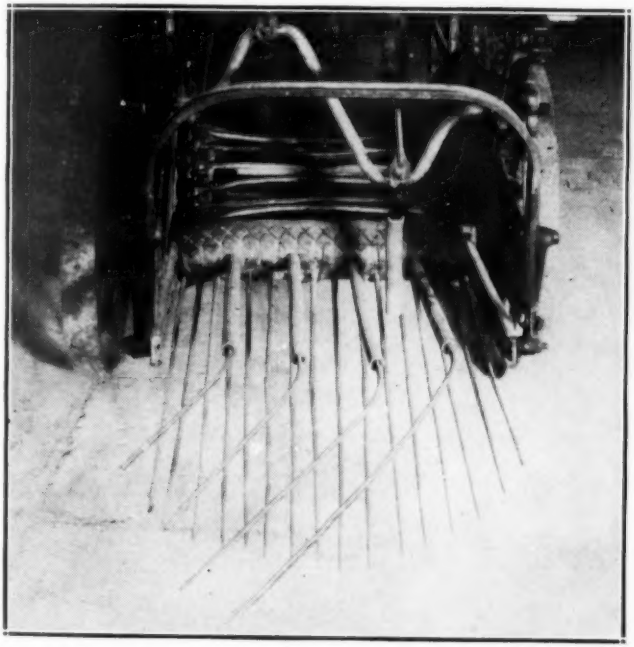

Fig. 1—Shaker Bar Digger (Padded)

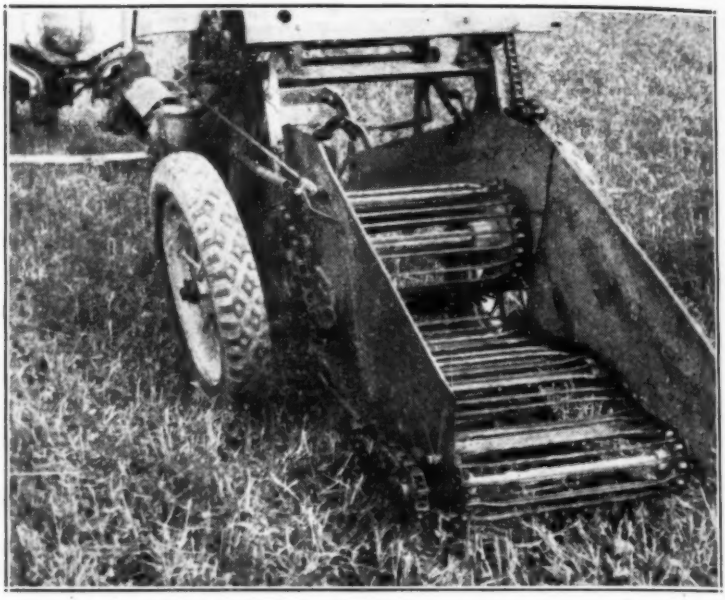

FIG. 2—EXTENSION ELEVATOR DIGGER

FIG. 3—CONTINUOUS ELEVATOR DIGGER

Type of Digger

Following the advent of the shaker-bar type of digger, came the extension-apron and still later the continuous apron type. Hardenburg (1) found in a field survey of 251 New York farms in 1931 and 1932 that the continuous apron type bruised fewer tubers than either of the other types in common use. The continuous apron feature eliminates the rear drop of tubers and their consequent injury by the contact with iron rods. In the field demonstrations reported here, it was often convenient to compare two and sometimes all three types on the same farm and under identical digging conditions as indicated in the tabulated summary. In 8 of 9 comparisons of the continuous apron digger with the extension elevator type, the former resulted in less tuber-bruising by an average difference of 8.66 per cent, which is highly significant. In 4 of 5 comparisons between the extension apron and the shaker-bar type, bruising was least with the shaker-bar machine. Here the difference was only 2.6 per cent and is not significant. Finally, in 12 of 13 paired comparisons of the continuous apron type with the shaker-bar digger, results were distinctly in favor of the former. The average percentages of bruised tubers were 1.92 and 10.46 per cent respectively, the difference of 8.54 per cent being highly significant with odds of 1428 to 1.

Conclusions

Seven factors involving types of potato diggers, their adjustment and operation as related to tuber bruising were studied on 32 New York farms over a three-year period. On the basis of the reduction in bruising obtained in these studies, speed of the apron, type of digger, and depth of digger point may be considered most important under prevailing conditions. However, it is obvious that attention to any one or a combination of several of these factors may result profitably to a potato grower according to his specific conditions.

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SOME EVIDENCE ON THE SPREAD OF BACTERIAL WILT

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Since the discovery of bacterial wilt and ring rot there has been considerable speculation regarding the amount of spread in the field. Workers, particularly Racicot, Savile and Conners (5) recognized the serious nature of the disease and the fact that it was easily spread, and therefore recommended a zero tolerance for this disease on certification standards. Bonde (1) has shown that an increase in bacterial wilt of 50 per cent may occur in a seed lot in one season. He has also shown that "a relatively high percentage of the plants grown in close proximity to the wilted plants contracted the disease." Bonde (1) and Racicot, Savile and Conners (5) demonstrated that diseased plants may be produced by tubers showing no symptoms, and the senior author (2) has found gram positive bacteria in apparently normal tubers and vines. Bonde (1) stated that more work was needed to determine the distances that the disease may be carried under field conditions, and it was partly for this reason that the present work was undertaken. This report pertains only to conditions as they are found in the field and sheds no light on how infection occurred.

Two fields of Katahdin potatoes, which had been rejected for certification at the time of second field inspection, on the 25th of September were selected. Both fields were from the same seed stock and were grown under irrigation. The inspection reports showed 2.5 per cent visible symptoms of bacterial wilt. In each of these fields plants showing symptoms of bacterial wilt were selected. The plants were pulled from the soil and stem smeared. About one-half inch of the underground stem was cut off with a sharp knife and the cut surface was pressed on a glass microscope slide. Stem smears were then made from each of the three plants below this one in the same row and also from the two plants above. Four plants were stem smeared in each of the next two rows on either side of the row containing the plant showing symptoms. One plant was stem smeared in each of the second two rows on either side also. These two plants were directly opposite a plant showing symptoms. (See tables 1, 2 and 3). Fifteen plants were stem-smeared around each plant showing symptoms. Fifteen sets of stem smears were made in Field 1, and 17 sets in Field 2, a total of 32 sets or 512 individual plants. The stem smears were then stained and

examined under the microscope for the presence of gram positive bacteria, following the method described by Racicot, Savile and Conners (5) and in use at the Colorado Experiment Station (3 and 4).

Results

The number of plants showing gram positive bacteria in the various positions in relation to the plants showing symptoms are shown in tables 1, 2 and 3, and the percentage of plants in each position in relation to a plant showing symptoms are shown in tables 3, 4 and 5.

An examination of the tables show that a larger number of plants down the row from a plant showing symptoms became infected than the number that became infected up the row. By down the row is meant the direction in which irrigation water travels. Similar results

TABLE 1

Number of Plants Showing Gram Positive Bacteria in Field 1. Fifteen Sets of Plants Were Used in Each Position. (The plants showing symptoms are underscored)

		4			
	5	7	10		
6	6	15	7	7	
	3	7	8		
	7	5	6		
		4			

TABLE 2

Number of Plants Showing Gram Positive Bacteria in Field 2. Seventeen Sets of Plants Were Used in Each Position. (The plants showing symptoms are underscored)

		5			
	9	6	8		
9	4	17	6	7	
	6	10	7		
	8	7	9		
		7			

TABLE 3

Plants Showing Gram Positive Bacteria in Both Fields. Thirty-two Plants Were Used in Each Position. (The plants showing symptoms are underscored)

		9			
	14	13	18		
15	10	32	13	14	
	9	17	15		
	15	12	15		
		11			

TABLE 4

Percentage of Plants in Each Position Showing Gram Positive Bacteria in Field 1

		26.67		
	33.33	46.67	66.67	
40.00	40.00	100.00	46.67	46.67
	20.00	46.67	53.33	
	46.67	33.33	40.00	
		26.67		

TABLE 5

Percentage of Plants in Each Position Showing Gram Positive Bacteria in Field 2

		29.41		
	52.94	35.29	47.06	
52.94	23.53	100.00	35.29	41.18
	35.29	58.82	41.18	
	47.06	41.18	52.94	
		41.18		

TABLE 6

Percentage of Plants in Each Position Showing Gram Positive Bacteria in Both Fields

		28.13		
	43.75	40.63	56.25	
46.88	31.25	100.00	40.63	43.75
	28.13	53.13	46.88	
	46.88	37.50	46.88	
		34.38		

are reported by Bonde (1) but he found no infected plants in the row above the source of infection. It seems evident that water plays some part in the dissemination of this disease, as reported also by Bonde (1) but does not account for the high amount of infection found in the first and second rows on either side and opposite the source of infection and above the source of infection in the same row. In Bonde's experiments the infection did not appear to spread extensively beyond the first row, but in these trials the number of plants showing infection in the second row was at least as high as in the first row removed from the source of infection. No conclusions can, however, be drawn from this work regarding the distance of spread, as the amount of infection exceeded expectations and too small an area was included, as may be seen from the tables. At least 14 additional positions should have been included and disease-free seed stock should have been used surrounding diseased plants. A total of 200 plants from a possible 480 plants in the two fields which surrounded plants showing symptoms, were infected. This is 41.67 per cent of the fifteen plants surrounding one showing symptoms, or it means that at least six plants are infected in addition to the one observed on the basis of external symptoms. The seed stock used here must have contained a trace of the disease in 1938, which increased to 2½ per cent of visible symptoms in 1939, and on the basis of this work is at least 18 per cent infected at harvest time.

The large amount of spread across two rows and up the row has already been noted. This spread can hardly be accounted for by irrigation water. The most prevalent insect in Northern Colorado is the flea beetle. From the data here presented, this insect might most logically be suspected of disseminating this organism.

This work also indicates that a zero tolerance is justified, at least, as far as foundation seed stock is concerned

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REPORT ON POTATO VIRUS DISEASES IN 1939

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This report gives a review of some of the papers on potato virus diseases published during 1939 and the latter part of 1938. Not all these papers were read, and in some cases only the abstracts found in the Review of Applied Mycology were used.

Dennis (8) conducted studies to determine the properties of Solanum virus 4 (= virus B) from an Up-to-Date potato plant freed from contamination of virus X by passage through the X-immune U.S.D.A. Seedling No. 41956. The symptoms induced by this virus were studied on 18 additional hosts, of which *Datura stramonium* and tomato were found to be the most valuable for diagnostic purposes. The former host reacts by a bright systemic mottle with slight necrosis and deformity, and the latter by a characteristic yellow interveinal mottle. It was found possible to infect King Edward and Arran Crest potatoes with virus 4 by sap inoculations, the virus being recovered unchanged following infection by this method. In the case of other varieties, sap inoculation results in the production of local lesions only. The virus was inactivated by exposure to a temperature of 70° C., but not at 65°, and it resisted dilution in tobacco sap to 1:100,000, and survived in expressed juice for six weeks.

Black (1) succeeded in transmitting the yellow dwarf virus by means of grafting or the leafhopper vector, *Acerotagallia sanguinolenta*,

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to the following plants: *Nicotiana glutinosa, N. langsdorffii, N. sylvestris,* Semple's Shell Pink China Aster (*Callistephus chinensis*), Crimson Clover (*Trifolium incarnatum*), broad bean, *Nicotiana rustica, N. paniculata, N. Sanderae,* Turkish tobacco, *Physalis pubescens,* and Black Beauty egg plant. In all cases the virus was transferred from the new host to Green Mountain potatoes or *Nicotiana glutinosa.*

Thirteen hundred and fifty primary lesions were obtained on a single half leaf of *Nicotiana rustica* inoculated with the yellow dwarf virus from the same host, the foliage in some cases being so heavily infected that complete yellowing rapidly followed. In inoculation tests by the carborundum method of leaf-rubbing, *N. rustica* proved to be more susceptible to infection by the yellow dwarf virus than any of the five plants from which the inoculum was procured, potato, *N. glutinosa,* Turkish tobacco, *Hyoscyamus niger,* and Crimson clover. Experiments undertaken to determine the best method of mechanical transmission in the potato showed that the most satisfactory results (50 per cent infection) were secured by placing juice from severely diseased leaves around the eye of an unsprouted seed piece and making about 100 punctures through the juice into the flesh of the tuber.

The primary-lesion reaction was applied in the determination of certain properties of the virus, which was found to succumb in the juice of *Nicotiana rustica* after 2½ to 12 hours exposure (23° to 27° C) and did not survive a week's desiccation in leaves of the same host in the laboratory. The virus was inactivated at a temperature of approximately 50°.

Walker and Larson (22) give a description of the symptoms of yellow dwarf under Wisconsin conditions. The non-emergence of plants from infected seed tubers is an important phase of the symptomatology not previously reported. The top symptoms are severe at high temperatures and may be entirely suppressed at 16° C. or lower. Low soil temperatures favor germination and emergence from infected seed tubers and tend to suppress the appearance of top symptoms. High soil temperatures tend to prevent emergence and also to hasten the appearance of top symptoms. No field evidence of spread by the potato leafhopper or aphids was secured. No correlation was found between red clover plantings and yellow dwarf epidemics.

Dykstra (9) conducted studies to determine whether aucuba mosaic, Canada streak, pseudo-net-necrosis, and tuber blotch corresponded to viruses found on potatoes in the United States of America, and whether there was a natural relationship between the different viruses causing the yellow mosaics. Studies such as serological reactions, protective

inoculation, determination of thermal inactivation point, longevity of virus *in vitro*, and symptoms and general behavior of the disease were used to determine whether there was a natural relationship among the viruses under study. The results showed that pseudo-net-necrosis and tuber blotch were identical, and that tuber blotch, Aucuba mosaic and Canada streak showed strain relationship, but no natural relationship was found between the viruses of the Aucuba mosaic group and the calico virus.

On the basis of recent researches, Köhler (12) has grouped the viruses of the X type into two groups. One X^e comprising strains inactivated at 75° C, and the other X^n represented by those succumbing at 68°. Variability is considerable within both groups, which include very weak strains spreading slowly in tobacco, moderately active ones with a normal faculty of permeation, and very powerfully necrotic strains diffusing relatively slowly. The view that both groups belong to the same virus species X, is upheld by the following criteria.

(1) Representatives of one group may be used for protective inoculation against those of the other. (2) Members of both groups agree exactly in respect to sensitivity to heat. (24 hours exposure to a temperature of 50°). Koch's potato mottle virus may constitute a transitional phase between the two categories under discussion.

Köhler (15) found that a strain of potato virus X Cs 36 was readily induced to form an abundance of aberrant weak strains by heating the infective crude juice of tobacco plants to the inactivation limit (66° C.), but the same procedure was ineffective in the case of the weak strain Cs 35, which originally gave rise to Cs 36. The mutants developing from the homogeneous strains of Cs 35 and Cs 36 differ not only quantitatively, but also to some extent qualitatively, from their parents. So far, the strains derived from Cs A are classifiable in four groups according to the intensity of the symptoms produced in inoculation on tobacco.

On the basis of field observations in 1937 at Dahlem, Berlin, Köhler (14) classified 26 potato varieties into four groups, the first comprising varieties susceptible to both leaf-roll and virus Y; the second those susceptible to leaf-roll, while their reaction to virus Y is not clear; the third those susceptible to virus Y with an uncertain reaction to leaf-roll; and the fourth those with reduced susceptibility (either active resistance or tolerance) to both viruses. A more thorough trial of Altgold, Flava, Jubel, Parnassia (all group IV), Centifolia, Sickingen, Voran (all group I), and Stärkeriche (II), showed that none was resistant to leaf-roll, although Altgold, Jubel, Flava,

Voran, and Parnassia possessed a high degree of tolerance, being just as receptive to the virus as the strictly susceptible varieties but suffering little or no injury. Altgold and Jubel were highly tolerant and Parnassia moderately tolerant of virus Y. The yields of Altgold, Flava, Jubel, Voran, and Parnassia remained relatively stable for three successive years, whereas those of Centifolia, Sickingen, and Stärkereiche decreased considerably owing to infection. The yield of Voran, which showed severe symptoms of disease, compared surprisingly well with others, indicating a considerable tolerance of both viruses.

It is concluded that by means of transgressive breeding a much higher degree of resistance to, or even immunity from virus Y could be achieved. It is believed, also that a higher degree of tolerance can probably be obtained, and it is suggested that some of the varieties in group II may prove more resistant than the 8 tested.

Loughnane and Murphy (17) conducted studies on the dissemination of potato viruses X and F. Virus F was found to be transmissible by leaf contact under the same conditions as virus X.

From the existing evidence it is thought that some of the potato viruses are spread exclusively by leaf contact, *e. g.*, virus X and the virus complex X + B, some by insects or by both biological and mechanical means, with mechanical transmission predominating, *e. g.*, virus F, by both means with biological transmission predominating; *e. g.*, virus Y, and some by biological means only; *e. g.*, leaf-roll and possibly virus A.

Forster and Costa (10) describe a disease found naturally on tobacco and commonly referred to a "Vira Cabeca" (crooked top), in the state of Sao Paulo, Brazil. The symptoms on tobacco are characterized on the leaves by clearing of the veins and rugosity, reduction in size, malformation and necrosis, of fern leaf and ring spot patterns. A general yellowing of the plant commonly precedes its death. Recovery was observed in a few instances, and the recovered plants produced flowers.

Artificial transmission of the disease was obtained by grafting, and by means of leaf mutilation, but only a very small percentage of infection was secured by the latter method as only 1 of the 23 plants inoculated became infected.The disease was also transmitted by Franliniella sp., but not by aphids presumably *Aphis-gossypii*. Tomato plants were also found to be susceptible.

Costa and Forster (5) repeated transmission studies on the disease "Vira Cabeca" (crooked top) and confirmed the results secured in a previous publication (10). The primary symptoms in tobacco are

evident from 3 to 12 days after inoculation, and secondary symptoms after 4 to 21 days. It is pointed out that spotted wilt and crooked top are probably the same, or are caused by a closely related virus. A description is given of the symptoms on tobacco and tomato plants. The results indicate that the best source of inoculum is secured from young leaves with secondary symptoms of recently affected plants.

Costa and Kiehl (6) conducted further studies on "Vira Cabeca" (crooked top). The senior author has described the same disease on tobacco and tomato in two previous papers (10). A new disease of potato tentatively referred to as top necrosis and caused by the virus of "Vira Cabeca" is described. In addition to a top necrosis of the stem, tubers from infected plants show brownish necrotic areas in the pith and cortex. The disease was found in various potato fields, even where tobacco and tomato plants, the common host of the virus, were never grown. Inoculations from potatoes to tobacco and tomato gave typical symptoms of the disease caused by crooked top. There is no resemblance between this disease and other types of top necrosis, but it does resemble in some respects yellow dwarf, although these two diseases are not considered to be identical.

Clinch *et al* (3), founded upon an examination of four different crops of Champion and five of Arran Banner from a stock believed to be virus free in 1928, that showed from 40 to 66 per cent and 38 to 94 per cent of virus X infection, respectively, no matter how isolated they had been when grown in the seed producing district of Donegal from five to seven years; 2 to 6 per cent infection with virus A occurred in three crops, and 4 per cent with virus B in three crops, accompanied by X in all cases; no other viruses were found. Seven crops of Champion from a stock proved to be virus-free in 1931, grown in moderate commercial isolation in the field in Donegal from four to six years, showed complete absence of viruses X, Y, A, G, E, F, and leaf-roll. The importance of the present Irish policy of building up seed potato stocks free from all viruses, including X, is stressed. It is concluded that the potato crops can be maintained free from viruses transmitted through contact by growing the potatoes in moderate isolation, whereas freedom from insect-borne viruses can be easily achieved in districts where both the viruses and vectors are scarce.

Chouard and Dufrenoy (2), give the details of experiments conducted in a mountain reserve of France which proved that selected stocks of Majestic potatoes from Ireland, free from leaf-roll and virus Y, are apt to contract these diseases even at high altitudes unless precautions are taken to isolate the planting site, *e.g.*, by a pine belt, from such

sources of infection as old "degenerate" potato stands and cabbage crops infested by aphids. Living aphids were found at an elevation of 2,200 meters. No infection occurred on plants raised from virus-free Dutch seed. The yields of healthy potatoes at a height of 1,850 meters above sea level greatly exceeded those obtained in well known centres of production in the plains.

Salaman (18) found that the control of the two most destructive virus diseases of the potato in England, leaf-roll and leaf drop streak, depends on the removal of sources of infection, destruction of carriers other than potatoes and roguing, the planting of clean seed, and the use of immune varieties for seed purposes. Solanaceous weeds which may be infected with leaf-roll and the X and Y viruses must be completely eliminated from potato-growing areas.

Störmer (21) found that for practical purposes the virus diseases affecting the German potato crop may be divided into two groups, (1) comprising those transmitted by the peach aphid (*Myzus persicae*), namely leaf-roll, streak, and virus A, and (2) virus X the means of transmission of which has not yet been reported, but it is in any case independent of *M. persicae*. Under the dry climatic conditions found in the potato-producing areas of Northeast Germany, even thorough and repeated roguing does not result in the unqualified success in virus elimination reported from Holland. The extension of peach cultivation necessitates the application of an insecticide to the trees during dormancy, and also the treatment of the potato crops with nicotine. Early harvesting, before the virus has time to pass from the foliage to the tubers, is another method of control that is widely practiced in Holland. There are, however, certain physiological drawbacks to this procedure; attempts have been made to replace it by the destruction of the aerial organs with strong concentrations of copper sulphate.

Experiments are now in progress to obtain disease-free material by isolating potato clones in the midst of cereals, each potato plant or progeny from a single plant being separated from similar units by 3 meters of winter barley. So far the results appear to be promising.

Crepin *et al* (7) conducted comparative tests from 1932 to 1937, with two Dutch varieties, and one German grown from imported seed practically free from disease, and the French variety Industrie, completely infected with mild mosaic, at altitudes of approximately 200 meters and 850 meters in the Jura; 650 m. in the Morvan; and 1,550 m. in the Savoy Mountains. At the lowest altitude the spread of virus diseases was very rapid. At the higher altitudes it was much slower, and the degree of infection was much less intense, this effect apparently

increasing with the altitude, though the minimum elevation for the production of disease-free material cannot be determined since variable environmental, climatic, and ecological factors affect dissemination. The authors claim to have shown that healthy potato seed can be profitably produced in certain mountainous regions of France and that the country ought to utilize its numerous mountains for the production of all the seed potatoes it needs for itself and its colonies.

Cockerham (4) found that the maximum acreage under Majestic, King Edward, and Kerr's Pink potatoes rejected on account of leafroll in Scotland occurs in the Southeastern area. The disease was a common cause of rejection in Arran Consul, Gladstone, and Dunbar Cavalier.

Severe mosaic is of economic importance only in the Southwest, where the locally cultivated potato varieties fall into four groups according to their reactions to viruses A and X, viz., (1) lethally necrotic to both, (2) lethally necrotic to A but not to X, (3) lethally necrotic to X, but not to A, and (4) non-lethal to both. Group 1 comprises King Edward, Epicure, and Ninety Fold; Group 2, Kerr's Pink, Door Star, Great Scot, Eclipse, Sharpe's Express, Redskin, Duke of York, *etc.*; Group 3 may be ignored for practical purposes; Group 4 may be sub-divided into (a) containing varieties commonly found to be infected by virus A, namely Golden Wonder, Arran Chief and Catriona, and (b) represented by the remaining non-lethally reacting varieties, Majestic, Arran Banner, etc. The rejections in Groups 1, 2, 4a and 4b, on account of severe mosaic, amounted to 0.80, 0.64, 12.72, and 1.25 per cent, respectively. The incidence of the disease in the Southwest was shown to amount to 7.52, 1.94, 30.74, and 6.94 per cent, respectively, for the foregoing groups, compared with maximum of 0.50, 1.35, 14.50, and 1.14 per cent, respectively, for other parts of the country. The chief agent of severe mosaic in Group 1 is virus Y, which is localized in the Southwest; in Group 2 it may be due to X, Y, or X + Y; in Group 4a to A + X or A + X + Y; and in 4b to A + X, A + Y, or X + Y.

The percentages of stock seed (99.95 per cent pure and containing no diseases except neglible mottle), Grade A (99.5 per cent pure and not exceeding 1 per cent mild and severe mosaic, leafroll, and wilding) and H. (not more than 3 per cent severe mosaic, leafroll, and wildings) in Group 1 where 4.28, 67.96, and 26.18, the corresponding figures for Group 2 being 0.27, 12.10 and 72.60, and for Group 4b, 0.28, 6, 58, and 85.28, respectively.

Studies in Scotland (19) have demonstrated the significance of the top necrosis reaction to viruses A and X, conferring virtual immunity in

the field. Seedling 451-a, derived from a cross between Epicure and Pepo and possessing this type of response, has been placed on the register of new varieties after only two years' testing.

Net necrosis of Golden Wonder, Arran Consul, Kerr's Pink, and possibly other varieties, appear from four years' investigations to be associated with primary leaf-roll of which, however, it is not a constant symptom, and has been observed in only 91 of the 724 known cases.

Attempts at the elimination of virus diseases from German potato fields have hitherto consisted mainly of the removal of infected material by roguing. Heinze and Profft (11) recommended the elimination of *Myzus persicae* by eradicating the commercially unimportant peach and apricot orchards in the vicinity of the potato fields.

After emphasizing the important part played by *Myzus persicae* in the transmission of virus diseases of the potato in Germany and the consequent need for drastic reduction or at least the effective insecticidal treatment of peach stands in the vicinity of production centers, Köhler (13) calls attention to the suspected implication of *Apris rhamni*, in the dissemination of virus A. Fuller knowledge of the migratory phases of both *M. persicae* and *A. rhamni* will facilitate the insecticidal operations on the peach and the field spraying of potatoes.

Loring (16) conducted experiments to determine the yields and relative or specific activity of the latent potato mosaic, virus (X) obtained from *Nicotiana glutinosa* and Turkish tobacco, and prepared by chemical treatment and centrifugation, revealed wide variations in relative activity according to the method of purification employed. In general, repeated precipitation with salt or acid produced preparations of low and variable activity, as compared with the uniform high activity displayed by those resulting from ultra centrifugation. There were no marked differences in the properties of the active and relatively inactive preparations, both having the same qualitative solubility, serological relations, ability to traverse ultra filters of approximately 450 Mû average pore diameter when dissolved in nutrient broth, and 01M phosphate at PH 8.5, and capacity for the formation of liquid crystalline solutions which are, however, more opalescent in the case of the inactive preparations and give highly diffuse boundaries in the analytical ultra centrifuge.

The analysis of virus purified by ultra centrifugation are those of a nucleo-protein containing some 6 per cent nucleic acid. Qualitative tests and the isolations of a material with the qualitative solubility of yeast nucleic acid also point to the presence of pentose nucleic acid.

The ratio of carbohydrate to phosphorus is about twice that determined by the same analytical method for yeast nucleic acid. The lat-

ent mosaic virus is relatively unstable below PH 4.0, but stable from 7.5 to 9.0 in diametrical opposition to tobacco mosaic.

The relatively high degree of homogeneity of the virus purified by the ultra centrifugation of clarified infectious juice, as shown by its uniform specific activity, and its ability to pass ultra filters of 450 Mμ pore diameter, are considered to indicate that such preparations are essentially identical with the infectious principle as it occurs in plant juice.

Stevenson *et al* (20) conducted studies to determine inheritance of immunity from virus X in the potato. The inheritance of this immunity was studied in crosses between S 41956 and two non-immune varieties, in a progeny of S 41956 selfed, and in progenies of two other immunes selfed. Thirty-seven per cent of the progenies of the two crosses and from 72 to 78 per cent of the selfed lines were found to be immune. The results can be explained by the usual type of inheritance of autotetraploids.

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SECTIONAL NOTES

CALIFORNIA

Potato harvesting in the Stockton District continues to be very active.

The Shafter Deal cleaned up earlier than usual and the movement from the Stockton District until the present time is considerably heavier than usual. A very large percentage of the present crop is moving by truck to close-in territory.

The present prices on U. S. No. 1 Grades range from $1.35/1.45.

The quality of the Stockton Crop on an average has been very fine, but it is too early to determine what the exact yields will be.

A large volume of Army and Navy business has been coming in, including business from the Hawaiian Islands. On the other hand, the export business to the Philippines and the Far East is much lighter than usual because of the uncertain conditions existing at the present time. (Aug. 12).—E. MARX.

INDIANA

For the last month and a half, Indiana has been quite dry and warm and the late crop, no doubt, has been seriously damaged by the hot and dry weather that has prevailed. The Cobblers, for instance, will yield a

very light crop and be a little later than usual. We are just starting the main harvest of the early-planted Cobblers and these are showing excellent quality and also good yield. There is some damage in the ground to the formed tubers because of the extremely warm weather, but this is rather slight. Chippewas and Katahdins,—especially the Katahdins, look very well at this time and appear to be withstanding the drought much better than any other variety grown in the state. These are also being tested at our muck crops farm in the northern part of the state. Potato growers are continuing to apply control measures. This year the spray materials seem to be much more effective than the dust. (Aug. 10).—W. B. WARD.

MAINE

The Aroostook County Farm Bureau Field Day held on the 7th of August was very well attended, as there were about three thousand people present. Much interest was shown in the experimental plots. The speaker, Dr. Stevenson of the U. S. D. A., was well received. In his talk, Mr. Stevenson dealt with new varieties of potatoes in a humorous manner.

Of the notable events in August were the New England sessions of the National Fertilizer Association at Presque Isle on the two days prior to Field Day, namely the 5th and 6th of August, followed by attendance at the Farm Bureau Field Day. These sessions were well attended. Mr. Chas. J. Brand and Mr. H. R. Smalley of the National Fertilizer Association were on the program together with Dr. J. A. Chucka and others from the Maine Experiment Station.

Among many others who also attended was Mr. Fred H. Bateman, manufacturer of Iron Age Planters, who has shown unflagging interest in the proper placement of fertilizer. Most of the recent progress in methods of fertilizer placement have been brought about because of his untiring efforts.

A rather unique incident in political campaigns occurred recently during a political tour when Sumner Sewall, Republican candidate for Governor, urged farmers to use the facilities of the Experiment Station and Extension Service more fully. This is so unique that it deserves special attention. More often than not candidates for Governor, or other political candidates for that matter, know so little about Research or Extension that they completely ignore it. Needless to say, many of us think it is a very sound farm program.

August has been dry throughout Aroostook County with the exception of heavy showers during the first of this week, the 13th of

August. The growers in the southern portion of Aroostook and central Maine are suffering severely from drought, they are not as yet experiencing the showers that the central portion of Aroostook enjoyed.

The potato vines are becoming mature. Later varieties are holding up well except in those fields where blight is prevalent. By the way, there is considerable blight showing up throughout Aroostook,—principally in the central and northern portions. The poorly sprayed fields are noticeably damaged, whereas in the better-sprayed fields show that some blight is present, although the plants are not seriously affected.

On the 22d of August we are looking forward to the visit of "Spike" Evans, National Administrator of the A. A. A. He will speak to the members of the Community, County, and State Committees, then returning to Augusta on the following day, he will speak in that city on Saturday.

There is very little interest in seed or table stock "futures." At the present time not so many potential buyers are visiting Maine as did a year ago. Nearly every one is pessimistic about the immediate future and prospects for the winter are not, by any means, clear and will not be for some time. (Aug. 18).—FRANK W. HUSSEY.

NEBRASKA

The first inspection of Nebraska Certified fields will be practically completed by the end of the week,—the 10th of August. A few fields of extreme late planting still remain to be inspected. The second inspection will take place immediately,—particularly on irrigated fields.

The inspections to date, show that the quality of the 1940 crop is materially improved over the previous season. This is especially noticeable with the lower disease readings for spindle tuber. Very few fields have been rejected for this disease. Two factors are probably responsible for this improvement, namely, better quality seed stock, taken from seed plots the previous year, and the reduction in grasshopper population during 1939.

Inspectors have reported that *Fusarium eumartii,* which causes stem rot is appearing throughout the territory. As a whole, the per cent of the disease that is showing at present is low, but it is too early in the season for its appearance.

Dry land fields, as a whole, are in reasonably good condition, though moisture is needed for most of the fields. The seed beds in most cases had ample moisture, and the potato plants are well established at this time. There is considerable tip burn, or firing due to the extreme heat

that has prevailed during the last two or three weeks. This is not a serious condition, if cooler temperatures prevail before long. If we have cool temperatures and moisture by the end of August, a good dry land crop can still be harvested.

The irrigated potatoes, as a whole, have a good stand, and look very good at the present time. Their situation, however, is not so favorable as the usual season, because of a shortage of storage water. Some of the main ditches in the North Platte Valley have shut down, and others will shut down during the coming week. This is a serious situation, because the potato plant has its largest water requirements during the month of August. At least one additional watering is necessary, and in most cases, two will be required to produce the usual crop.

Various observers of the irrigated potato crop in the North Platte Valley estimate that it will be not more than 50 to 60 per cent of the 1939 crop. Even if we should have rains during the latter part of August, the probability is that the crop will be quite short, compared with last year. This lack of water, at a critical time, is likely to increase the amount of Fusarium (stem end discoloration) in the potatoes, as was the case in 1938. These factors reduce the quality of the crop.

Pump irrigators, which represent a small portion of the total irrigated crop in western Nebraska, are in a much more favorable position. Their crop is in very good condition, and with proper management, they should have excellent yields. A number of the ditch irrigators in the North Platte Valley have supplementary pumps, which will relieve the situation for them. Others are attempting to supplement their water supply at the present time by pumping equipment.

The insect situation, particularly with regard to Blister Beetles, is fairly well under control. Many territories, particularly the dry land areas, had a great deal of difficulty this season. It was necessary to spray from three to four times before the trouble abated. Grasshoppers, as a whole, have been much less numerous, and in some cases, have practically disappeared this season. This is the first season in three or four years, that the grasshopper situation has been definitely better.

In central Nebraska, in areas around Burwell and Ord, the early potato crop was in excellent condition until the middle of July. The late potato crop, which is comparable to western Nebraska is becoming well established, and should produce yields similar to those in western Nebraska. This is a new territory, and growers are experimenting with various dates of planting, and various varieties, to determine what is most desirable for their territory. In those areas harvesting of the

crop planted in early April has been in progress for two or three weeks. The early crop is of good quality. Considerable difficulty has been experienced with sunscald. This means that digging has been confined to the early and late hours of the day, in order to avoid that trouble. Prices received on the early crop broke sharply from $1.75 *per cwt.* to approximately 60c. Digging ceased entirely, and the Surplus Commodities Division of the Department of Agriculture stepped in to buy some of the potatoes. This has bolstered the price, so that growers are now receiving 80c to 85c f. o. b. cars.— (Aug. 13).—MARX KOEHNKE.

NEW YORK

Weather conditions have been generally favorable for potatoes throughout most of New York to the present time. There has been plenty of rain in all areas, except recently in the extreme western end of the state where it is now too dry. The stands up state are probably below normal because of too much rain and cold during, and after planting. Long Island, apparently, will harvest one of its biggest crops of fine quality tubers. Yields of 350 to 450 bushels are reported in Nassau County. The harvest on Long Island may be a little later than normal because of the late spring planting.

In attempting to predict yields this year, the following conditions should be taken into account. Growth has been rapid following the generally high soil moisture level with the result that the foliage is very succulent and subject to scald, heat injury and blight. Some fields show signs of collapse as a result of the recent high temperatures and intense solar radiation. Late blight (*Phytophthora*) is generally present throughout the state as a result of the long wet season throughout May, June, and July. Loss in yield from blight will be considerable, but the final effects of blight will depend on the weather and the efficiency of spraying from this date on. In brief, the New York crop up to the critical midseason stage of development has been very promising. As stated before, everything from this date will depend on the weather and the efficiency of Bordeaux application. (Aug. 10).—E. V. HARDENBURG.

OREGON

The first potatoes of the 1940 crop were shipped in carlots on the 1st of August, two weeks in advance of normal. Apparently the acreage is somewhat greater than that of last year but the entire crop is somewhat advanced. Some diseases are making their appearance but

more than 90 per cent of the seed stock entered for certification in Klamath County passed the first field examination.

Our certified acreage is about the same in Klamath County as in 1939, subject of course to further field inspection as well as bin and laboratory examination.

With the exception of advanced maturity, the general condition of our crop in this county seems about normal. (Aug. 13).—C. A. HENDERSON.

PENNSYLVANIA

There were more than 1500 acres of potatoes entered for certification in Pennsylvania this year compared with 1208.0 acres entered for inspection in 1939. The largest acreage entered was of the Russet Rural variety with 763.5 acres; White Rural, 242.5; Katahdin, 283.0; and Nittany and Cobbler 142.0 acres. Other varieties were Houma, Bliss Triumph, Chippewa and Green Mountain.

Most fields show more disease this year than usual. It is believed that the unfavorable seasons that we have experienced during the past two years are responsible for this disease. Leaf roll and mosaic were not so easily identified during the last two years as they were this year. This made it more difficult for the roguers to rogue the fields thoroughly.

Growing conditions during the early part of the year were very favorable for potato growing with the result that those fields which were planted early made a heavy vine growth. Since the advent of hot weather these fields are going down quite rapidly. Some areas in Pennsylvania are dry at the present time.

We have begun to harvest the early varieties. The yields are good, although scab is quite serious. All growers report a good marketable size. (Aug. 14).—K. W. LAUER.

SOUTH DAKOTA

All the potatoes in South Dakota suffered from the extreme heat from the 16th to the 24th of July but have made a partial recovery because of the rains received since the 24th. The yields on the higher ground will not be so large as last year.

With the increased acreage of certified seed the total tonnage will be almost as much as in 1939. However, there will be more "B" size this year.

Harvesting will start in approximately two weeks. The early plants are now dying down. The quality of the stock will be very good and the Bliss Triumph variety will be of very good seed size.

One new warehouse is under construction and two more may be built. (Aug. 12).—JOHN NOONAN.

VERMONT

Except for a comparatively few plantings that were made early in May before the wet period began, potato fields got off to a very late start. Growing conditions during the latter part of July and the first part of August have been excellent, however, and indications as of the 15th of August point to a good yield. Practically no late blight has made its appearance.

There are slight increases in the number of growers entering for seed certification and in enrolled acreage, which brings the total for the latter up to approximately 475. An apparent heavy increase of virus diseases last season, coupled with ideal conditions for disease determination this season, has made some bad records for some seed lines, and the percentage of rejection,—especially for leaf roll, is heavier than for several years.

A well-attended meeting of the Vermont Certified Seed Potato Growers' Association was held at the State School of Agriculture, Randolph Center, on the 14th of August, with John Tucker, chief of seed certification in the Dominion of Canada, as the principal speaker. (Aug. 17).—H. L. BAILEY.

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POTATO VARIETIES RECENTLY DISTRIBUTED TO GROWERS IN THE UNITED STATES

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The annual meeting of the Potato Association of America held in Richmond, Virginia, December 28-30, 1938, adopted a resolution as follows: "Whereas many members of this Association and many potential subscribers to the American Potato Journal are intensely interested in the adaptation and annual performance record of the newer potato varieties, and whereas such information is not now conveniently available in summary form for the United States and Canada as a whole, therefore, be it resolved that an annual summary report on this matter be made available by the United States Department of Agriculture at our annual meeting and for publication in the Potato Journal."

In response to this resolution, the writer of this report, on July 18, 1939, wrote to the agricultural experiment stations in the forty-eight states and Hawaii, asking for information concerning the behavior of the following varieties: Chippewa, Earlaine, Houma, Katahdin, Mesaba, Nittany Cobbler, Pennigan, Pontiac, Red Warba, Sebago, Sequoia and Warba. The varieties, it will be noted, are arranged alphabetically. They are discussed in alphabetical order also, and not in the order of their importance. The reports at best are fragmentary and although it might be desirable to draw

[1]Senior Geneticist.

conclusions and make recommendations, they might be more misleading than helpful. It is thought best, therefore, to give the data very much as it came from the different states and let the statemen draw their own conclusions and make their own recommendations. A few general facts are, however, apparent. As is to be expected, all twelve varieties are not adapted to the same potato-growing sections, but each of those that have been tested to any great extent is proving its superiority in certain areas and meeting definite needs.

Chippewa is increasing in importance in Maine, Rhode Island, parts of New York State, Michigan, Wisconsin, Ohio, Oklahoma and the northern sections of Idaho. The increase is caused by its resistance to mild mosaic, high yielding ability and market quality. Its cooking quality is variable. In some sections it is quite satsfactory; in others it ranks lower than the old standard varieties. It often sells at a premium, but this is because of its high market quality. One of its worst features is a tendency for the leaves to roll, under adverse conditions. It is almost impossible to distinguish this rolling from the true leaf-roll resulting from virus infection. This makes the Chippewa very difficult to rogue.

The Earlaine has not been tested so extensively as the Chippewa. Under favorable conditions, such as frequently occur in Maine and in certain sections of New York State, it produces satisfactory yields of tubers of high market quality. It is not, however, so widely adapted as the Irish Cobbler and when the conditions are adverse the Cobbler will consistently outyield it.

Houma would be grown more extensively if seed were available. This variety has done well in some of the New York tests. It is also promising in Maine. If Katahdin and Chippewa had not been introduced first in that state the Houma would be grown more extensively in Ohio. It is resistant to mild mosaic, and is reported to be more resistant to heat injury than some of the standard varieties. The variety Houma also produces a good crop of tubers with relatively high cooking quality.

Katahdin was the first variety to be introduced by the United States Department of Agriculture and as a result is the most widely known. It is firmly established as a commercial variety in Maine, Michigan, Ohio, Colorado, parts of Idaho, Louisiana and the Hastings district of Florida. It has been on the increase in Maine because of the demand for seed. Its freedom from mild mosaic and the smaller amount of leaf-roll infection as compared with other

varieties make it highly desirable. In Michigan it usually outyields the Rurals and there are outlets for Katahdin seed that would not be available for Michigan Rurals—for example, Louisiana and Florida. The Katahdin is increasing in production in Ohio because of its vigor and the high market quality of its tubers, which often command a premium in price.

Mesaba is an early variety that produces tubers of high market quality. Like Earlaine, it makes a fine crop under favorable conditions but does not compete with the Cobbler under adverse circumstances. It has a thick rugose leaf, a character that adds to the difficulty of roguing for virus diseases.

Nittany Cobbler has apparently done well in its home state of Pennsylvania, judging from the increased acreage of certified seed found in that state. In other sections the reports have stated that it cannot be distinguished from the Irish Cobbler.

Pennigan, another Pennsylvania product, is on the increase in that state also. Reports from other states indicate that it is quite similar to the White Rural.

Pontiac is a red-skinned variety from a cross of Triumph and Katahdin. This variety produces tubers of higher market quality than the Triumph. However, it is later than some strains of the latter variety. It is high-yielding, especially on muck soils. Pontiac will find a place in sections where a red variety is desirable and where earliness is not the most important factor in potato production.

Red Warba, an early high-yielding variety, originated as a mutation from Warba. As a variety it compares favorably with the early strains of Triumph in yield but is discriminated against in some sections because of a tendency to form tubers with large splashes of white on their skin.

Sebago is a late, high-yielding variety resistant to mild mosaic, late blight, and to tuber rot initiated by the late blight fungus. It is in great demand in Maine and other sections where late blight epidemics occur all too frequently and where in years favorable for such epidemics spraying with Bordeaux mixture fails to control the disease. Generally speaking, it will produce a satisfactory crop without spraying most years, and it is doubtful if it would ever become infected with the disease to any great extent if susceptible varieties such as Green Mountain were not planted in close proximity.

Sequoia is the newest member of the group. This is a selection from a cross of Green Mountain and Katahdin. It produces high yields of tubers in western North Carolina and western Maryland, but it has not been tested sufficiently to determine its behavior in other sections.

A few scattered reports indicate that it yields well in Maine and Massachusetts. The Sequoia has proved tolerant to flea beetle and leafhopper injury in North Carolina and has not been so severely injured by late blight as have some of the commonly grown commercial varieties.

Warba is on the increase in its home state of Minnesota, and to a lesser degree in other states where it has shown high yielding ability. Its tubers are characterized by rather deep, pink eyes, a condition that causes them to be discriminated against on some markets.

To this point the writer has given his interpretation of the reports, but for those who might wish more detailed information regarding the behavior of these varieties, brief summaries from the reports follow.

Chippewa

Chippewa in Alabama, in 1939, could not be considered superior in yield to any of the three standard varieties—Triumph, White Rose or Irish Cobbler. In Arizona, it was quite promising from the standpoint of yield. At Experiment, Georgia, in 1938 it yielded less than Houma, Warba and Sebago. In one of the tests in Hawaii, the Chippewa was discarded because of spindle tuber; in another, it gave a higher yield than British Queen, but the difference was not significant. A comparison with the Bliss Triumph showed a significant difference in favor of the latter variety. The Chippewa seems well adapted to Northern Idaho. Its resistance to mild mosaic is an advantage there. All reports from Iowa growers regarding Chippewa vary widely. Under favorable conditions some excellent crops of nice smooth potatoes have been secured and in other seasons under conditions of high temperatures, small crops of small tubers have resulted. For some reason it does not seem to be highly tolerant to heat. There has also been a complaint that it is susceptible to "hair sprout" caused, perhaps, by poor stock. It seems to be a very promising variety for Louisiana. In Maine it compares favorably with Green Mountains in yield. On twenty-nine farms in Aroostook County in 1938 Chippewas outyielded Green Mountains by seventeen barrels per acre and returned nine cents more per barrel than the same grade of Mountains. In Maryland the Chippewa is recommended for planting where a smooth, shallow-eyed potato is desired which is one week to ten days later in maturing than the Irish Cobbler. In Massachusetts the Chippewa at present is leading in yield. In the state 300-bushel contest in 1939, it was found in both first and second places. Eight of the twenty-four records taken were from Chippewa yields. In Michigan, the Chippewa is more promising than it is

in any other state. It appears now as if it might replace, to a large extent, both Katahdin and Russet Rural. The report from Nevada indicated that it was very poor in tests there. In one test in New Hampshire, Chippewa yielded as much as Irish Cobbler, but approximately only one-half as much as Green Mountain. The conclusions from preliminary tests in New Mexico are that Chippewa will not compete with Irish Cobbler there. The average yield for Chippewa for fifteen tests in New York State was 193 bushels per acre, as compared with 213 bushels for Green Mountain. In twelve comparisons with Pioneer Rural, Chippewa yielded 192 bushels per acre, Pioneer Rural 249. In Western North Carolina, the Chippewa has given satisfactory yields, being inferior only to the Sequoia in this respect. Chippewa is widely grown in Ohio, gradually superseding Russet Rurals, except on soil where scab is serious. It matures three weeks earlier than Rurals and ten days later than Cobblers. Secondary growth, a serious defect of early-planted Rurals, has never been reported on Chippewa in the six years it has been grown in Ohio. Susceptibility to scab limits the acreage in that state. Average yield is about the same as Russet Rural. It has proved particularly valuable for muck soils because it can be cleaned more easily than Cobbler. The Chippewa is too late maturing to fit well in Oklahoma. In Rhode Island the Chippewa has been increasing in favor with a number of commercial growers. It is reported as a high yielding potato with excellent appearance, but not equal to Green Mountain in cooking quality. Chippewa in South Carolina has not been a consistent yielder. Some years it gives very high yields, whereas other years it drops off to a relatively greater degree than Katahdin or Irish Cobbler. Some growers are afraid of Chippewa because of a relatively high percentage of leaf roll found in their fields in 1938. In South Dakota it is reported as a good yielder in long, favorable seasons, but on the average slightly lower than Bliss Triumph, Irish Cobbler and Early Ohio. It is susceptible to spindle tuber. The tubers have excellent appearance and eating quality. Vermont reports that quite a number of growers have tried Chippewas and more would do so were it not for the fact that leaf roll had become so prevalent in it. It is not considered to have very good quality. At Pullman, Washington, Chippewa yielded 283 bushels of marketable tubers, as compared with 222 for Netted Gem and 207 for Irish Cobbler. In West Virginia the Chippewa seems to be adapted to the intermediate altitudes (2,000 feet) and does exceptionally well on light soils. It was affected only slightly by hoppers and flea beetles and very little by early blight. It has evidently come to stay, as many of the growers are quite enthusiastic about it. From Wisconsin, the following report

was made: "Chippewa, a mid-season variety exhibited a state-wide adaptation range. Tubers oval, shallow-eyed, tend to hold true to type under adverse growing conditions; skins extremely white and easily bruised; usually free from hollow heart. A promising variety for Wisconsin, frequently demanding a premium on table stock markets."

Earlaine

In most tests in Colorado, Earlaine has not been promising. In some cases disease interfered with the tests. Earlaine has failed to yield with Cobblers and Triumphs in four of the early producing sections for three years. In 1939, however, in one of the early districts it produced an excellent crop and is being continued on the basis that it may find a place in the state. At Hastings, Florida, Earlaine yielded one hundred and eighteen bushels per acre, as compared with 190 for Spaulding Rose. Another unfavorable report came from Iowa: "The vine growth on this variety was rather meagre and the vines weak. The yield was light and has been light for the past two seasons and does not appear to be promising for this section. In Louisiana the yields for all the early varieties were small, but the Earlaine compared favorably with the others." On the eastern shore of Maryland the average yield for Earlaine for two years was 222 bushels of U. S. No. 1's as compared with 237 bushels for Irish Cobbler. In western Maryland the comparison was even less favorable. The conclusion is drawn that since Earlaine is smoother than the Irish Cobbler and probably more desirable on the markets, even if it yields somewhat less, it is recommended as an early variety for the state. It has not given satisfactory yields in Rhode Island. In New York from eleven tests made in 1938, there was no significant difference in yield between Earlaine and Irish Cobbler, but in ten comparisons in the same year it was outyielded by Warba. In fourteen tests in 1939, however, Earlaine was outyielded by both Irish Cobbler and Warba. It made its best showing on the muck soil at Genesee where it yielded 266 bushels per acre as compared with 264 for Warba and 287 for Irish Cobbler. Earlaine has been dropped from the tests in western North Carolina, because it cannot compete in yield with Sequoia and Chippewa. In Ohio it was tested only one year. It matured a week later than Cobbler and did not yield so well. The Cobbler grown in Ohio produces a comparatively smooth tuber with

shallow eyes, except at the bud end, so that the smoother tubers of the Earlaine do not have a distinct advantage. The report from Oklahoma showed that Earlaine yielded about the same as Warba, but was outyielded by the early Triumph in the spring crop of 1939. H. A. Joslyn of East Hardwick, Vermont, reported in 1939, "The Earlaine made a short, stocky vine that died early, but made a good crop of fair sized round handsome potatoes despite the dry weather. I am much pleased with this variety for an early potato. They set a good many tubers to the hill and should have room and fertile soil to avoid too many small ones. They made a poor showing last season, as they were full of spindle tuber, but I have them quite clean now, I think." At Onley, Virginia, they yielded approximately the same as Warba in 1939, but they were outyielded by Irish Cobbler. The Pullman, Washington, report gave low yields for all the early varieties and again Earlaine was outyielded by Irish Cobbler. From West Virginia the report showed that Earlaine had been grown there for the first time last season. The tubers were very attractive, but their performance was not outstanding.

Houma

The Houma has been tested for a number of years in different parts of Colorado, but has not been outstanding in any of these tests. In the San Luis Valley in 1939, it yielded 285 bushels of marketable potatoes per acre, as compared with 342 for Katahdin and 327 for Bliss Triumph. At Montrose, the yields were 252 bushels per acre for Houma and 283 for Katahdin. At Experiment, Georgia, in 1938 it yielded 140 bushels of U. S. No. 1 potatoes, as compared with 105 for Chippewa and 93 for Katahdin. At Honolulu, Hawaii, Houma yielded about the same as Katahdin, but much less than Sebago. Houma is being distributed in northern Idaho and will be grown extensively because of its resistance to virus diseases, and its greater resistance to drought than the varieties commonly grown in that area. The report from the Massachusetts Agricultural Experiment Station for 1939 placed Russet Rural first, Houma second, and Green Mountain third in the order of yield. Russet Rural yielded 19 per cent higher than Green Mountain, and Houma 17 per cent more than the latter variety. Houma yielded 167 bushels of U. S. No. 1 potatoes at Lake City, Michigan, as compared with 200 for Russet Rural. The report from Durham, New Hampshire, was more favorable.

At Colebrook, New Hampshire, the Houma set heavily and produced attractive potatoes. It yielded at the rate of 325 bushels per acre, as compared with 375 for Green Mountain. At Chichester it yielded 317 bushels per acre, and Green Mountain yielded 323. In New York, Houma was compared at twelve different locations with Green Mountain and Smooth Rural. The mean yields for these twelve tests were 189 bushels of U. S. No. 1's for Houma; Green Mountain, 221; and Smooth Rural, 242. Houma was tested in North Carolina from 1933 to 1937 after which time it was discontinued, since it was not considered superior to the standard varieties. In Ohio, it was similar to Katahdin in time of maturity and yield. It would be considered a most valuable new variety had not Chippewa and Katahdin been introduced first. It would be recommended for commercial production if seed were cheaper than that of Chippewa. Yield data from Oklahoma show that in comparable tests it yields about the same as Triumph. In South Carolina, Houma has compared favorably with Irish Cobbler, but not enough better to warrant using it as a replacement for Cobbler. Houma, at Brookings, South Dakota, has given satisfactory yields in long favorable seasons, but over a period of years the average is slightly lower than for the early varieties—Bliss Triumph, Irish Cobbler and Early Ohio. In 1938, the cooking quality of Houma was inferior. The Vermont report indicated that the Houma possessed a heavy vine and a very heavy root system, but did not seem able to make so good a crop as Green Mountain under the drought conditions of 1939. On the other hand, under drought conditions in Washington State, Houma yielded 263 bushels of marketable potatoes per acre in comparison with 220 for Netted Gem. Houma appears to merit attention in West Virginia. It also showed promise under conditions favorable to Chippewa.

Katahdin

Katahdin in Alabama yielded about as well as Cobbler, but not quite so high as White Rose or Bliss Triumph. It has apparently proved satisfactory in Coconino County, Arizona, since about 90 per cent of the acreage in that district is planted to that variety. In California it has not made any headway. It has been tried in a number of districts, but has been discriminated against because of its cooking quality or because the market in that section prefers long tubers such as are produced by the White Rose or the Burbanks. In the San Luis Val-

ley of Colorado it gives very satisfactory results. In the Hastings District of Florida it is replacing Spaulding Rose. The 1939 report said in part, "The climatic conditions were very favorable for the development of brown rot and the disease would have caused much greater losses throughout the Hastings section if the brown rot resistant variety, Katahdin, had not been grown on 7,000 of the 13,707 acres planted." It has shown enough promise in Hawaii to be considered for further trials. The Katahdin is replacing some of the old commercial varieties of potatoes in northern Idaho. It seems especially adapted there because of its high yield and greater resistance to drought and viruses than the commonly grown varieties. From Illinois it was reported that Katahdin has been grown to some extent in the northern counties, but the potatoes formed too near the surface of the ground and were thus subject to greening. The Iowa report states, "This variety has shown up very well in Iowa as to yield, but it is too late for this section and has also been criticized as to its cooking quality, probably due to immaturity." The reports from Louisiana for 1939 showed high yields for Katahdin, as compared with Bliss Triumph in both the spring and fall tests. The acreage is rapidly on the increase. It seems that it is an excellent variety for that region and its commercial production is being encouraged in every possible way. In an Extension report of a study in Aroostook County, Maine, the following statement is made: "On twelve farms growing both Katahdins and Mountains, Katahdin yields exceeded those of the Mountains by eighteen barrels to the acre." The quality of the Katahdins grown in Maine does not, on the average, equal that of the Green Mountains, but the seed growers are interested in their production, since the demand for seed is increasing. Two characteristics of this variety, the immunity in the field from mild mosaic and the tendency to escape the high percentage of leaf-roll infection that is too often found in the Green Mountains, have added to the popularity of the Katahdins as far as the production of seed is concerned. Maryland is recommending the Katahdin to growers in the state "who wish a smooth, round potato with shallow eyes, which is resistant to mild mosaic and which will mature ten days to two weeks later than the Irish Cobbler. Yields somewhat larger than the Irish Cobbler may be expected from the Katahdin potato in Maryland, especially on the Eastern Shore." The Katahdin does not seem to be able to compete with the Chippewa and Green Mountain in Massachusetts. On the other hand, the Katahdin variety has been grown extensively in Michigan for the past few years. It is believed, however, that Chippewa is replacing both Katahdin and Russet Rural. Several of the better growers still think the Katahdin a good variety

to grow, especially on the lighter soils. The increased demand for seed in Louisiana and Florida will probably encourage its continued production. In Nevada the Katahdin has been grown for a number of years. It has been very free from blight, but has been somewhat infected with scab. It produced large yields, and, in fact has outyielded Russet Burbank at least 67 bushels per acre. The market, however, does not take too well to the Katahdin. It bakes and fries well, but is not so good for boiling and mashing. The New Mexico report indicates that the Katahdin has been considered inferior to the Irish Cobbler in the tests so far. In New York in 1939 the average yield for fifteen tests for Katahdin was 199 bushels of U. S. No. 1's per acre and that for Green Mountain 213. The difference is probably not significant. On the other hand, in twelve tests, the Pioneer Rural yielded approximately 45 bushels per acre more than did the Katahdin. In the western sections of North Carolina, Katahdin has been outyielded by Sequoia and Chippewa. It is not so popular as Chippewa in Ohio. It matures a week later, produces large vines and is somewhat more difficult to spray than is the latter variety. Potatoes are not hilled in Ohio and as the Katahdin has a tendency to set its tubers near the surface of the ground, a relatively large percentage of them become greened. The yield, appearance and quality are almost identical with Chippewa. Katahdin has given satisfactory results in certain parts of Pennsylvania. In one test in Potter County in 1939, however, the Sebago outyielded the Katahdin by 47 bushels per acre, a difference that may or may not be significant in a limited test. In Rhode Island, Katahdin has not yielded so well as Chippewa or Green Mountain and is not increasing in commercial production so rapidly as Chippewa. It has been the most consistent high-yielder of the new varieties at the South Carolina Station at Charleston for the past three years. Growers who have tried it in that section seem well impressed with it and there will probably be an increased acreage of it planted in 1940. The main objection is the fact that it is a little later than Irish Cobbler, but this is partially offset in that on the average it will give higher yields than the latter variety. South Dakota reported that the Katahdin gave good yields in long favorable seasons, but on the average slightly lower than Bliss Triumph, Irish Cobbler and Early Ohio. It is susceptible to the major diseases, especially spindle tuber. The tubers are excellent in appearance and table quality. They are sometimes phenomenally large. A report from Harold L. Bailey, Director of the Division of Plant Pest Control, Department of Agriculture, Vermont, said, "In the case of the Katahdin, we have been certifying four or five small lots each year for several years and some growers who have raised it seemed well satis-

fied with it. Few, however, feel that it is of as good eating quality as the Green Mountain. It yields about equally with the Green Mountain and its freedom from mosaic and apparent resistance to leaf-roll seemed to make it a good bet in certification. I am somewhat surprised that more growers have not taken it up, especially in view of what appears to be a good market." The Washington State report shows that under rather adverse conditions, the Katahdin yielded 263 bushels per acre of U. S. No. 1's, as compared with 220 bushels for Netted Gem. West Virginia has had Katahdin under test for a number of years. It does not perform quite so satisfactorily as does the Rural. During the past season it was badly infested with leafhoppers and flea beetles, but showed no disease injury. Katahdin does not seem to be able to compete with Chippewa in Wisconsin. It requires a longer growing season than the latter variety, but about the same as Russet Rural. Its tubers are similar to those of Chippewa, but develop less hollow heart. This variety also exhibits some resistance to drought. In Wyoming, the average yield of Katahdin for three years was about the same as Chippewa, but not so high as Red McClure. The yield however, was higher than that of the Irish Cobbler, Russet Rural, and Bliss Triumph.

Mesaba

The Mesaba is an early variety. It has not been tested extensively, but a few reports have been received. Colorado reports that the tuber is excellent, but the character of the vine makes it almost impossible to rogue for spindle tuber. It has not yielded with Irish Cobbler and is not being recommended for introduction in the state. In Florida, the Mesaba yielded very poorly at both Hastings and Federal Point. Pontiac and Sebago yielded approximately three times as much at Hastings, and more than twice as much as Federal Point. In Iowa it is more promising. There the vine growth is moderate; yield, good; tubers exhibit a desirable shape; and the skin stands handling very well. The season is a little later than that of the Cobbler. The rugose character of the foliage lends to the difficulty of roguing. This is perhaps its worst fault. In one test at Amherst, Massachusetts, it yielded about the same as Cobbler but in another test in Bristol County in which it was compared with Green Mountain and Sebago, it was outyielded by both of these varieties. At Ithaca, New York, Mesaba was outyielded by a number of varieties, among which were Cobbler, Warba, Chip-

pewa and Green Mountain. It yielded satisfactorily on muck in the Genesee tests, although it was outyielded there by Cobbler, Chippewa, Earlaine and Warba. In Ohio, the Mesaba has been tested for one year. It matured a week later than Irish Cobbler and did not yield so well. Then, too, the tubers of Mesaba were not distinctly superior to those of the Cobbler. In West Virginia, the Mesaba has been observed for only one season and does not seem particularly outstanding in any way, but will be tested there again. It was moderately affected with early blight, tip burn and flea beetle injury. In Wisconsin it matured about the same season as Irish Cobbler. It has an improved tuber shape, but was inclined to be more susceptible to virus diseases than the latter variety.

Nittany Cobbler

From reports received, it might seem that the Nitanny Cobbler has not been tested very extensively. In Nevada, from 25 pounds of seed planted, 240 pounds of potatoes were produced. Seed, when cut had hollow centers, but the crop of tubers was not so affected. Nittany Cobbler tested one year at the Agricultural Experiment Station, Wooster, Ohio, could not be distinguished from the Irish Cobbler. Considerable acreage is planted in Ohio, but there are no reports of premiums for seed such as are paid for Chippewas and Katahdins.

Pennigan

The Pennigan which was tested only one year in Ohio appeared to be a good strain of White Rural. It did not outyield the Russet Rural.

Pontiac

The Pontiac was tested in three locations in Colorado in 1939. It had an excellent vigorous vine, but the tubers were too rough. This variety is inferior to the Red McClure in this respect. At the mountain substation it yielded 373 bushels per acre, as compared with 327 bushels for Brown Beauty. Pontiac produced a higher yield at both Hastings and Federal Point, Florida; at Hastings yielding 247 bushels per acre of U. S. No. 1's, as compared with 238 for Sebago and 190 for the Spaulding Rose. It was outstanding in yield also at Federal Point, with 401 bushels per acre, as compared with 367 for Sebago and 285 for Spaulding Rose. An-

other favorable report came from Iowa. This variety has been grown in a limited way on the Ames plots for the past three years and has shown a number of desirable characters. It possesses a high degree of heat endurance and seems to have the ability to re-establish itself quickly after a drought. It is a smooth tuber and does not form knots when rains follow periods of drought, a character that is a serious fault of the Early Ohio. In Michigan the Pontiac continues to give high yields, especially on muck soils. The yield data for East Lansing and Lake City for the two years 1938 and 1939 show that Pontiac yielded 218 bushels of U. S. No. 1's with 4.4 per cent off-type tubers and Russet Rurals yielded 201 bushels and 28 per cent off-types. At Ithaca, New York, Pontiac outyielded the Irish Cobbler and Katahdin, but was in turn outyielded by a number of other varieties, including the Green Mountain, Chippewa and Houma. In the Genesee tests on muck soil, it did not seem to be so outstanding as it was on the Michigan mucks. In these tests it yielded 271 bushels per acre, as compared with 305 for Katahdin, and 287 for Irish Cobbler. The only comment from the Wooster, Ohio, tests is to the effect that Pontiac grown at the Experiment Station in 1939 had deep eyes, such as are characteristic of some of the McCormick group. West Virginia reported that Pontiac was planted at three places and proved to be a very vigorous and high yielding variety. It was average in susceptibility to leafhoppers and flea beetles. The tubers were exceptionally solid, round and smooth and from a single season's observation; it seems to have possibilities if the West Virginia market will take a red potato. In Wisconsin, the Pontiac matures about the same season as the Russet Rural. The tubers are oval, smooth, and dull red; the vine growth sturdy; and the yields satisfactory.

Red Warba

Red Warba, a mutation from the Warba, does not differ from the latter variety except in color. Warba produces white tubers with pink eyes; Red Warba red ones with splashes of white. The red variety has not been tested so extensively as the Warba, but it should be adapted to approximately the same conditions as the parent variety.

A few reports have been received. Alabama reported that the Red Warba has been tried out at different times, but its streaked color makes it unattractive, and it is rather rough. At Hastings,

Florida, Red Warba was outyielded by only two varieties—Sebago and Pontiac—but at Federal Point there was no significant difference among the mean yields of these three varieties. At this station all yielded significantly higher than Spaulding Rose. The Warba and Red Warba were in the same class with respect to yield at both stations. The Red Warba yielded about the same in Louisiana as the Warba. In the spring test in 1938 it yielded 174 bushels per acre, as compared with 147 for Triumph, but the yields are not strictly comparable, since the seed of the two varieties came from different sources. At Ithaca, New York, the Warba outyielded the Red Warba, but the latter variety had 47 per cent leaf roll, which could easily account for the difference. Observations in Oklahoma this past year indicate that there is very little difference between the Warba and Red Warba, except in skin color. The Red Warba has been tested in a very limited way in West Virginia. The report from that state indicates that the Red Warba and Warba appear similar in habit of growth and seasonal requirements. They both set heavy. The Warbas are not particularly desirable from the market standpoint and the Red Warbas are definitely less marketable, because of their variegated color. In the Wisconsin tests the Red Warba matured a week earlier than did Triumph. Both the tuber shape and size were similar to Triumph,—with a bright red skin color. It appears to be a promising first-early variety for central and southern Wisconsin, frequently outyielding Triumph.

Sebago

Sebago has been grown in Colorado for only one year. Yield data were not taken, but it appeared to be a very promising variety. It showed a slight resistance to scab, but was very susceptible to psyllid yellows, as are all the commonly grown commercial varieties. Sebago was tested in Florida at Hastings and at Federal Point. It outyielded the Splauding Rose by 48 bushels per acre at Hastings and by 82 bushels at Federal Point. It was tested in Georgia in 1938. All the yields were low, but it outyielded Chippewa and Katahdin. It was reported, too, to be resistant to early blight. In Hawaii, the Sebago yield was encouraging, although it did not exceed British Queen so much as Bliss Triumph in one test, but it exceeded the latter in another test. It appears that Sebago will compete favorably with the standard white variety, British Queen, and yield possibly more than Bliss Triumph. Iowa

reported as follows: "Sebago has not been sufficiently tested in this state to warrant an opinion as to its value. On our plots in northern Iowa for the seasons of 1938 and 1939 it is at the top of the list in yield. Further tests will be needed to determine its value for this region." Sebago yielded fairly well in Louisiana. Reports from E. L. Newdick, Chief of the Division of Plant Industry in Maine, show that of the more than sixty small fields of Sebago entered for certification in Maine in 1939, not a trace of ring rot was found in any of them. The Maryland tests of Sebago have not been extensive, but the variety is recommended where a late, smooth, round variety with shallow eyes, resistant to late blight and mild mosaic, is desired. In twelve tests in New York State, Sebago yielded 225 bushels per acre, as compared with 249 for Pioneer Rural and 221 for Green Mountain. Sebago was tested two years in Ohio. It matured a week later than Russet Rural, yielded about the same, but the cooking quality was inferior. Because late blight is not common in Ohio, the Sebago is not likely to become popular in that state. It matures too late to fit well into production in Oklahoma. Two tests were reported from Pennsylvania. In one of these the Mason yielded 393 bushels per acre, the Sebago 325; in the other, Sebago yielded 322, and Katahdin 274. In Rhode Island, 30 sample lots were distributed, mostly a peck to each cooperator. Twenty-one of the records returned were usable. In these tests Sebago yielded 350 bushels per acre, whereas the standard varieties, mostly Green Mountains, yielded 305. At the Experiment Station, Kingston, Sebago yielded 390 bushels per acre, as compared with 348 for Green Mountain. 1939 was not a blight year in Rhode Island. The results show, therefore, that Sebago produces yields comparable with Green Mountains, even when the latter variety is not injured by late blight. The reports on cooking tests were generally satisfactory. One or two growers reported them as poorer in cooking quality than Green Mountains, whereas several reported that they prefer the Sebago. Sebago seems promising in South Carolina, but it will have to be tested more thoroughly before any recommendation can be made. It has given slightly higher yields than Irish Cobbler and has been free from late blight. One report from Vermont indicated that the Sebago was rather disappointing. It had a heavy vine and root system, but did not compare favorably with the Green Mountains under the droughty conditions that prevailed in 1939. At Onley, Virginia, all the yields were low in 1939 and the Sebago yielded only about ¼ as much as the Irish Cobbler. On the other hand, Sebago ranked second only to Houma in yield at Pullman, Washington, with 263 bushels of marketable potatoes per acre, as compared with 220 for the standard variety, Netted

Gem. The report from West Virginia said that Sebago is of considerable interest in that state. There was no late blight in 1939, but it seemed only mildly affected with flea beetles, leafhoppers and early blight, and under favorable conditions yielded well. In the Wisconsin tests Sebago was slightly later than Russet Rural, the tubers similar to those of Chippewa, the vines upright and sturdy, and the yield high. The Sebago, therefore, shows promise for areas interested in late potato production.

Sequoia

Sequoia is the newest variety of the group. It was named by the North Carolina Experiment Station in 1939. It has been in yield tests in the higher elevations of western North Carolina since 1933. This variety has been tested in a number of other states also as North Carolina No. 1 or North Carolina 130.5-24. It is a late variety selected from a cross of Green Mountain x Katahdin. Like all other varieties of potatoes, it excels in certain sections of the country, but is not adapted to conditions in other potato-growing regions. A report from Hastings, Florida, shows that it is surpassed by Sebago, Pontiac, Red Warba and Katahdin, so there would be no reason for growing it in that region. The Maryland Agricultural Experiment Station reported a yield at Oakland, Maryland, of 420 bushels per acre for Sequoia, as compared with 254 bushels for Pioneer Smooth Rural. A report from C. W. Clemmer, Manager of the Eastern States Farmers' Exchange, Springfield, Massachusetts, to M. E. Gardner, Raleigh, North Carolina, indicates the superiority of Sequoia in several characteristics. He reported a calculated yield of 517 bushels per acre field run. Under "diseases" he reported, "No diseases on either vines or tubers." Under "insects," "Severe infestations of insects, including aphids, flea beetles and tarnished plant bug; vines resistant to insect damage." One plot of Sequoia at Ithaca, New York, yielded at the rate of 300 bushels of U. S. No. 1 potatoes per acre in 1939. This was a much larger yield than was obtained from any of the remaining 33 varieties in the test. The season was exceptionally dry but the comparison is hardly fair, since the Sequoia was not included in the replicated tests as were the others. In a letter accompanying the report Dr. Hardenburg states, "I think you will understand that in the case of the Sequoia, although grown in the same field as the others, it was not included in the regular yield test, in fact, was

not even named when the seed was planted. Even so, the plants were exceptionally vigorous, healthy and late maturing and nearly all the tubers were classed as large. This might indicate that the variety is at least very drought tolerant. Its principal faults might seem to be extreme susceptibility to scab and a rather deeply recessed seed end." In the higher altitudes of western North Carolina it continues to surpass all other varieties tested in yield. In 1939 it produced at the rate of 401 bushels of U. S. No. 1 potatoes per acre in comparison with 208 bushels per acre for Chippewa,—its nearest competitor. The seven-year average, 1933 to 1939, inclusive, was 266 bushels for Sequoia and 188 for Chippewa. The report from Charleston, South Carolina, by J. M. Jenkins states, "Sequoia has proven to be a little too late for general planting in this area at the present time as it is about ten days later than Irish Cobbler, but it has given much higher yields than Cobbler in several tests, when left to mature. When dug at the same time as Cobbler, it has given about the same yields of No. 1 potatoes, but the tubers were, of course, very green." In the West Virginia trials, the Sequoia was very vigorous and relatively free from disease of any sort. It was affected only to a slight degree by leafhoppers and flea beetles.

Warba

At the Gulf Coast Substation, Fairhope, Alabama, Warba yielded 215 bushels per acre as compared with 185 for Cobbler; 183 for White Rose and 109 for the Triumph check. The report from Arizona indicated that Warba did not yield well in the higher elevations and was rather knotty, but trials are to be made in the low elevations. In Colorado, the Warba was discarded from the tests because of poor appearance, deep eyes, growth cracks and susceptibility to psyllid yellows and fusarium wilt. In Florida the Warba outyielded the Spaulding Rose at Federal Point, but there was no significant difference between their mean yields at Hastings. The Warba was tried out in the St. Louis area of Illinois, but was discontinued. Some reports were that it did not yield well, whereas others reported that it produced a large number of very small potatoes. A favorable report on this variety was received from Iowa. It is proving productive, is early and produces an attractive potato. The set is heavy and, if subjected to drought, a heavy set of undersized tubers results. On the other hand, under favorable conditions the yield is very good. The

one serious criticism is, deep eyes with heavy eyebrows. The Warba will find a place in Iowa as an early potato for the home garden and for commercial production of early potatoes on sandy areas. As grown on muck, it has not met with a favorable market response. Data from Louisiana indicate that Warba yielded about the same as Triumph, but much higher than White Rose in the spring of 1938 and higher than both of these varieties in the fall of the same year. The report from Massachusetts was not so favorable. Warba in the tests at Amherst did not yield so high as Irish Cobbler. As compared with other early varieties, the Warba yields high in Maine, although it is not favored from the standpoint of market quality. The results from a number of years' tests in Maryland indicate that larger yields can usually be expected from the Warba than from the Irish Cobbler, but more difficulty may be experienced in the control of certain diseases such as leaf roll, scab and late blight rot. In the Nevada tests, Warba produced strong, healthy plants and the tubers were very free from scab and blight. It appears to have a better appeal in the markets than Katahdin. At Colebrook, New Hampshire, the Warba yielded 205 bushels per acre as compared with 200 bushels for Irish Cobbler. The tubers are reported as keeping well in storage and are considered of good quality. In New Mexico, at elevations of 3,800 and 6,300 feet, the Warba was inferior to the Irish Cobbler. The reports from New York show that Warba yielded about the same as Irish Cobbler at Ithaca. In fourteen additional tests in the state, the Cobbler yielded 177 bushels, and the Warba 180 bushels per acre. It has not been tested in North Carolina for a number of years. The 1935 yield data indicated that it was inferior to Irish Cobbler and Triumph. The Irish Cobbler gave a yield of 250 bushels per acre; the Triumph 236; and the Warba, 218. It is increasing in popularity on the early sandy soils along the Ohio River; several cars of seed were planted there in 1939. The Warba was tested for six years at Washington County Farm near Marietta, Ohio. During four of these seasons it outyielded the Cobblers, on the average 50 bushels per acre. One season it was almost a complete failure, because of second growth. This condition did not develop on the Cobblers. The eyes of the tubers are deeper than those of the Cobblers under Ohio conditions. It is characterized by more plants per hill and consequently a larger number of smaller size tubers than either Cobbler or Triumph. In Oklahoma, the Warba yielded about the same as Triumph in the spring trials without irrigation, but in the spring crop grown with irrigation, it yielded significantly higher than the Triumph. South Carolina reported that the Warba produced yields comparable with Cobbler; in some

cases better than Cobbler, but the red eyes were termed "objectionable" to commercial growers in the Charleston area. The Warba is used as an early market potato in South Dakota. It does not produce so high a yield as do Bliss Triumph, Irish Cobbler and Early Ohio. It is susceptible to the important virus and fungous diseases. This variety has good cooking quality. However, its chief attribute is earliness. At Onley, Virginia, Warba did not yield so high as the Irish Cobbler in the 1939 tests. Warbas tested in West Virginia gave a heavy set of tubers, but it was found that a great deal depends on the season as to whether or not they attain marketable size. They are not particularly desirable from a market standpoint. In Wisconsin, Warba matured a week earlier than did the Triumph. The tubers were white, with deep pink eyes. The odd appearance makes them undesirable on the principal Wisconsin markets.

POTATO ROTATION STUDIES[1]

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Potato growers have believed for many years that the maintenance of large yields of potatoes was dependent on their being grown in rotation with other crops. The most common potato rotation in Upstate New York has been one of four or five years in length with two to three years of some hay sod immediately preceding the potatoes. Organic matter was rather easily maintained at a fairly high level with this practice. It meant, however, that potatoes were grown on many soils that probably were not well suited for that purpose. Shorter rotations, or the growing of potatoes on the same area each year would make it possible to select the best potato soils on the farm. The prevalence of tuber insects and diseases in the long rotations, particularly in potatoes following leguminous sods, has made it highly desirable to abandon these rotations in favor of the shorter ones.

A series of experiments were inaugurated in New York State in 1936 to determine the best rotation systems, green manures and cover crops and methods of growing and incorporating them in the soil for highest yields and quality of potatoes. The production of potatoes on

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[2]The authors are indebted to K. B. Nash and C. S. Tuthill for the data from the Franklin County and Genesee County plots, respectively.

the same area every year is compared with several two-year and five-year rotations. These experimental plots are located in three widely separated counties in the western and northern New York potato areas.

The systems of cropping employed in one of these experimental areas in Steuben County on soils of approximately pH 5.1 are as follows:

1. Potatoes every year, without cover crop, without manure (1 yr. rotation).
2. Potatoes every year, without cover crop, with 12 tons manure per acre (1 yr. rotation).
3. Potatoes every year, with rye cover crop, with 12 tons manure per acre (1 yr. rotation).
4. Potatoes every year, with rye cover crop, without manure (1 yr. rotation).
5. First year—potatoes with rye cover crop; second year—dry shell beans with rye cover crop (2 yr. rotation).
6. First year—potatoes with rye cover crop; second year—corn for green manure followed by rye cover crop (2 yr. rotation).
7. First year—potatoes with rye cover crop; second year—clover and timothy for green manure (2 yr. rotation).
8. First year—potatoes with rye cover crop; second year—dry shell beans seeded to winter wheat; third year—wheat seeded to clover and timothy; fourth year—clover and timothy hay; fifth year—clover and timothy (5 yr. rotation).
9. First year—potatoes with rye cover crop; second year—barley for grain seeded to clover and timothy; third year—clover and timothy hay; fourth year—clover and timothy hay; fifth year—dry shell beans (5 yr. rotation).

In the Franklin County plots in northern New York on soils of approximately pH 4.2 to 6.8 soy beans for hay are grown in the fifth eighth and ninth rotations in place of dry shell beans because the latter are not grown commercially in that area. Spring wheat also is substituted for winter wheat in rotation eight.

In the Genesee County plots in the limestone belt of western New York on soils varying from pH 5.3 to 7.3 sweet clover is grown in place of clover and timothy in the seventh rotation, and in the eighth and ninth rotations alfalfa is grown instead of clover and timothy.

In the Franklin and Genesee County plots a tenth system has been

added in which potatoes are grown every year on the same area with no cover crop, no manure and no commercial fertilizer. All other potato plots receive 1000-1200 pounds of 5-10-5 fertilizer per acre each year potatoes are grown. All plots are replicated five times and all crops in all rotations are grown every year. The plots are one-fiftieth acre in area.

Results

Early Death of Vines.—Marked differences in time of death or maturity of vines were first noticeable in 1937 between the various rotations. The data showing the number of dead potato plants in each rotation in Steuben and Franklin Counties are presented in table 1.

Table 1.—*Number of dead plants per plot on the indicated dates*

	Steuben Co.				Franklin Co.
Rotation No.	Sept. 20 1937*	Sept. 16 1938†	Sept. 23 1939‡	Avg. for 3 Yr. Period 1937-39	Sept. 8 1938*
Number	Number	Number	Number	Number	Number
10					187
1	136	129	170	145	208
2	64	34	85	61	92
3	60	32	81	58	64
4	140	122	186	149	228
5	113	167	175	152	222
6	162	144	193	166	123
7	134	74	151	120	97
8	105	73	122	100	102
9	107	131	167	135	186
No. required for significance by analysis of variance method: odds 19:1....	52	34	29	24	48

*Approximately 280 plants per plot.
†Approximately 290 plants per plot.
‡Approximately 255 plants per plot.

Steuben County.—During the latter part of August and early in September a number of potato plants turned yellow. As the season advanced the yellowing became more severe and in certain plots large numbers of plants died early. As shown in table 1, rotations 2 and 3 showed the lowest number of dead plants in each of the three years. With the exception of the annual application of 12 tons of manure per acre to rotations 2 and 3 they are handled the same as rotations 1 and

4, respectively. Apparently the application of manure is very effective in preventing early death of the vines. Plants in rotations 8 and 7 following two years sod in a five-year rotation and one year sod in a two-year-rotation respectively, also remained green longer than plants in any of the remaining rotations. No doubt organic matter alone is not the cause for this prolonged growth, since plants in rotation 6, where potatoes follow an enormous growth of corn plowed under as a green manure, died earlier than those in any of the other rotations.

FRANKLIN COUNTY.—On the whole, a similar situation existed here as in the Steuben County plots. Plants of rotations 2 and 3 again had the greatest number of growing plants on the 8th of September followed by those in rotations 7 and 8 in which potatoes follow sod. The most mature plants on the date of observation were in rotations 4, 5, 1 and

TABLE 2.—*Yields of potatoes on Steuben County plots. Variety, Smooth Rural*

Rotation Number	Yields of U. S. No. 1 (Bushels per Acre)					Total Yields (Bushels per Acre)				
	1936	1937	1938	1939	Ave. for 3-Yr. Period 1937-39	1936	1937	1938	1939	Ave. for 3-Yr. Period 1937-39
1	172	153	197	144	165	209	216	252	185	218
2	169	221	306	233	253	210	285	349	268	301
3	171	212	305	230	249	209	275	346	263	295
4	176	188	206	149	181	214	253	259	193	235
5	162	154	165	124	148	203	220	223	172	205
6	164	138	185	169	164	202	208	240	207	218
7	183	178	243	172	198	220	241	284	212	246
8	173	172	221	161	185	210	237	262	190	230
9	174	172	157	150	160	210	235	214	188	212
Bushels required for significance by analysis of variance method: odds 19:1	30	42	26	21	17	25	39	19	21	16

9, potatoes continuously without manure or potatoes following soy beans for hay in a two- or a five-year-rotation. It will be seen from an examination of the yield data of Steuben and Franklin Counties that, in general, yields show an inverse relation with the number of dead plants early in the season.

YIELDS OF POTATOES, STEUBEN COUNTY.—These experimental plots are located on a gravelly loam soil with a reaction, at the beginning of the experiments of pH 4.75 to 5.44. This area had been in regular cultivation for many years being cropped to potatoes, beans, small grain and clover and timothy hay. The yields of U. S. No. 1 size tubers and total yields for the four years are presented in table 2.

The cropping systems of all plots preceding 1936 were the same. Therefore, the yields the first year of these experiments in all plots should be similar unless variations in the soil should result in yield differences. The data of 1936 show no statistically significant differences in yields of any of the plots indicating a satisfactory distribution of the soil variability. In each of the succeeding three years, rotations 2 and 3 have consistently yielded higher than all other plots in both total yields and yields of U. S. No. 1 size. The high value of additions of manure to these soils is appreciated when comparisons are made between rotations 1 and 2 and between 3 and 4. The only difference in the handling of rotations 1 and 2 is that rotation 2 receives annual fall applications of 12 tons of manure to the acre. The same difference exists between rotations 3 and 4. Further experiments are being conducted on this same farm in an effort to detect the reasons for the large increases in yields following manure applications.

Of the three two-year rotations 5, 6 and 7, rotation 7, potatoes with rye cover followed by clover and timothy for green manure, has produced highest yields. This was followed in order by rotation 6, potatoes with rye cover followed by corn for green manure and a rye cover and rotation 5, potatoes with rye cover followed by dry shell beans with rye cover. Of the two five-year rotations, potatoes following two years of clover and timothy sod in rotation 8 have slightly but consistently outyielded potatoes following dry shell beans in rotation 9. Lowest yields have been obtained following dry shell beans in rotations 5 and 9, a two-year and five-year rotation respectively although they are not significantly lower than rotations 1 and 6.

Yields of rotations 1 and 4, potatoes every year without manure applications, are relatively low. Although all rye cover crops following potatoes were seeded late in October or early November and therefore produced little organic matter to plow under it apparently has resulted

in consistent although usually not statistically significant increase in yields as evidenced by yields of rotation 4 being greater than rotation 1.

FRANKLIN COUNTY.—In many respects the yields of potatoes on these plots are very similar to those obtained on the Steuben County plots. These data are presented in table 3.

TABLE 3.—*Yields of potatoes on Franklin County plots. Variety, Green Mountain*

Rotation Number	Yields of U. S. No. 1 (Bushels per Acre)					Total Yields (Bushels per Acre)				
	1936	1937	1938	1939	Ave. for 3-Yr. Period 1937-39	1936	1937	1938	1939	Ave. for 3-Yr. Period 1937-39
10	257	175	26	37	79	284	206	96	95	132
1	360	381	166	146	231	383	398	259	211	289
2	371	388	208	169	255	380	413	302	234	316
3	370	395	263	175	278	394	418	335	250	334
4	366	361	170	134	222	389	384	265	212	287
5	380	335	151	109	198	402	363	236	183	261
6	376	356	188	109	218	397	379	269	185	278
7	344	395	210	139	248	371	418	301	210	310
8	363	381	192	192	255	383	405	270	253	309
9	373	358	173	173	235	395	379	257	241	292
Bushels required for significance by analysis of variance method: odds 19:1	35	30	40	28	19	31	29	26	24	15

The soil of this experimental area is less uniform than that in the Steuben County plots as is shown by the variation in yields in rotations 1 to 9 during 1936 when all were handled the same. Yields of rotation 10, potatoes every year with no commercial fertilizer, manure or cover crop, are in every case significantly lower than all other rotations.

Because yields in rotation 10 were becoming extremely low an application of 12 tons of manure per acre was made in the fall of 1938. Some recovery has been made in the 1939 yields as is shown by the fact that in yields of U. S. No. 1 size rotation 10 is the only rotation yielding higher in 1939 than in 1938.

For the three year average, rotations 2 and 3, potatoes every year with manure applications, again produced higher total yields than any other rotation although these increases over rotations 7 and 8 are probably not statistically significant. In rotation 7 potatoes follow a one-year clover and timothy sod in a two-year rotation and in rotation 8 potatoes follow a two-year clover and timothy sod in a five-year rotation. The latter rotation is similar to that in use by many New York State dairy and potato farmers. Where certain types of wireworms are prevalent this rotation results in a very high percentage of injured and unsaleable potatoes. Often where soil is limed for the clover many scabby tubers are produced. In order to alleviate these troubles many growers now do not grow a hay crop immediately preceding potatoes although total yields in many cases may be high under these conditions.

With the exception of rotation 10 which has not received commercial fertilizer, rotations 5 and 6 have yielded the lowest. These are two-year rotations in which potatoes follow soy beans for hay and corn for green manure respectively. Potatoes continuously without manure in rotations 1 and 4 and potatoes following soy beans for hay in a five-year rotation, number 9, yielded approximately the same for the three-year period. Again rotation 3 with rye cover crop has slightly but consistently outyielded rotation 2 without a cover crop of rye. The difference probably is statistically significant.

Similar to results of the three two-year rotations in the Steuben County plots, rotation 7 yielded higher than rotations 6 and 5 and rotation 6 outyielded rotation 5. Likewise in the two five-year rotations potatoes following two years of clover and timothy sod have yielded higher than potatoes following soy beans for hay.

GENESEE COUNTY.—The soil of these experimental plots is a Honeoye silt loam ranging in reaction from pH 5.32 to 7.35. Preceding the initiation of the experiment this area contained a very luxuriant growth of alfalfa for 6 years and was in orchard crops preceding the alfalfa. It was therefore, in a high state of fertility and high in organic matter. The yield data are presented in table 4.

TABLE 4.—*Yields of potatoes on Genesee County plots. . Variety, Smooth Rural*

Rotation Number	Yields of U. S. No. 1 (Bushels per Acre) 1936	1937	1938	1939	Ave. for 3-Yr. Period 1937-39	Total Yields (Bushels per Acre) 1936	1937	1938	1939	Ave. for 3-Yr. Period 1937-39
10	31	320	299	187	269	44	349	316	223	296
1	28	303	319	215	279	37	347	339	245	310
2	24	297	307	229	278	31	318	319	253	297
3	30	311	319	212	281	39	356	334	227	306
4	34	322	301	209	277	47	364	317	227	303
5	23	315	322	273	303	32	354	332	292	326
6	28	311	328	299	313	31	354	341	321	339
7	32	318	353	228	300	41	363	365	243	324
8	18	317	319	228	288	25	356	330	243	310
9	30	312	334	239	295	39	356	350	262	323
Bushels required for significance by analysis of variance method: odds 19:1	20*	54*	75*	46	34	23	50	60	43	30

*No significant differences between any treatments.

The data for 1936 are of little value as the extremely low yields of all rotations were due to one of the most severe droughts experienced in that part of the state. Probably owing to the high state of fertility and large amount of organic matter in all of the plots and to considerable soil variation between certain plots there were no statistically significant differences in yields between any of the rotations in 1937 or 1938. In 1939, however, significant yield differences between rotations are evident. For the first time yields of rotation 10 are significantly lower than some of the other rotations, in this case particularly of rotations 5 and 6, two-year rotations with potatoes following dry shell beans and corn for green manure respectively. In total yields for the 3-year

period, however, rotation 10 has not yielded significantly lower than rotations 2 and 3 which are highest yielding in the Steuben County plots and rotations 7 and 8, which with rotations 2 and 3 are the highest yielding plots in Franklin County.

The highest yielding plots are of rotations 5 and 6. These rotations are of the lowest yielding plots in the Steuben and Franklin County fields. The low yields of potatoes following dry shell beans which was obtained in rotations 5 and 9 in Steuben County and soy beans for hay, rotation 5 in Franklin County were not obtained in Genesee County. Manure applications to rotations 2 and 3 have not increased the yields significantly if at all over similar rotations to which manure was not applied. There has been no satisfactory explanation offered for the wide differences in relative yields between rotations at the Genesee County plots compared with the Steuben and Franklin County areas. The state of fertility and organic matter content of the soils in the various plots may have caused these differences.

Summary

The early death of potato vines caused by differences in fertilizer and rotation practices results in yields inversely related to the number of dead plants at some early date.

Highest yields in Steuben and Franklin Counties are obtained in rotations in which potatoes are grown every year and in addition to commercial fertilizer they receive applications of 12 tons of manure to the acre. The highest yielding two-year rotation in these plots is number 7, potatoes following a one-year sod of clover and timothy grown for green manure. Lowest yields resulted in the rotation in which potatoes followed dry shell beans or soy beans for hay in the two-year rotation.

In the Genesee County plots no significant differences in yields existed among any of the rotations in 1937 or 1938. In 1939 the highest yielding rotations are of two years' duration, potatoes following corn for green manure and dry shell beans respectively.

Manure applications to the Genese County plots have not significantly increased the yield over similar rotations to which manure was not applied.

Extremely low yields were obtained in the Franklin County plots where potatoes were grown every year on the same soil without commercial fertilizer, manure or cover crop. A manure application in the fall of 1938 had a slightly beneficial effect on the 1939 crop. In the Genesee County plots such rotations until 1939, yielded as well as any other plots.

SECTIONAL NOTES

CALIFORNIA

A new official list of Surplus Foods available to families taking part in the Food Orders Stamp Plan was issued for the period from the 2d through the 30th of September, 1940.

This list differs from the previous list for the period from the 12th of August to the 1st of September, inasmuch as fresh cabbage and fresh corn were removed and fresh beets and fresh carrots were substituted.

Neither of the lists includes potatoes.

California potato growers and operators have been commenting upon this apparent omission inasmuch as potatoes are selling at extremely low prices which situation is recognized by the Department of Agriculture as indicated by the fact that large amounts of potatoes have been purchased for Relief in various potato-producing districts and we are further advised that potatoes in cooked or baked form, as well as soup, will be recommended by the Federal Surplus Commodities Corporation for inclusion in the Government School Lunch Program.

The intermediate California Potato Deals viz. The Santa Maria and Tehachapi Deals, are cleaning up earlier than usual this season.

Hereafter, California will be supplied principally from the Stockton Delta and the Klamath Falls Districts. (Sept. 11).—E. MARX.

INDIANA

A good general rain and also cooler weather have settled over Indiana which make our prospects for the potato crop a little brighter than they were a month ago. However, we still feel that there will be a 15 to 20 per cent reduction in yields of potatoes in Indiana this year because of the early drought. The quality of the potatoes is very good. Although the yields are not quite so large as expected in most instances, yet in the northern part of the state the yields will be high again. Our growers are going to watch their grading more carefully than ever before, for we have a number of cleaners and washers in the state at this time and quite a few growers are using their own branded sacks for the marketing of the crop.

Harvesting operations will be in full swing during the latter part of the month. (Sept. 6).—W. B. WARD.

Iowa

The state of Iowa has a small potato crop this year. The spring was late and cold and the seed was not awake and ready to grow, and there simply was not time enough before the extreme summer temperatures of mid-July.

Conditions which produced a fair crop, and in a few cases, excellent crops are (1) to have seed already start to germinate, (2) to use large seed pieces, (3) to cover shallow, and above all, and (4) have abundant humus. Wherever the spading fork went in full length easily and all other conditions were observed, there have been good crops.

We produce one to two million bushels of potatoes on our marsh soils and on these soils also the crop is small. The same conditions prevailed across the line in southern Minnesota. The spring appears to have been too cold for the making of good roots or for an early start and the mid-summer hot spell which was the second most severe on record seems to have been actually crippling to the potato crop.

If we had had much rain before the extremely hot weather, we would have expected the vines to die suddenly, but this they have not done. The vines are still clinging, doing a little but not much.

The size is not large, but the quality is good everywhere, except perhaps that our Cobblers may not be quite so mealy as common. There probably will be no kick upon the whiteness and mealiness of the tubers, but neither will there be as much enthusiasm as there is sometimes.

Probably the reason for not securing the highest degree of whiteness and mealiness has been the lack of as good vine shade to the ground as is usually secured, so that soil temperatures have been higher around the tubers. (Sept. 8).—C. L. Fitch.

Maine

A subsidy of 14½ cents per bushel on U. S. No. 2 grade potatoes, or better, was announced today by the Surplus Marketing Administration. It is expected that starch factories will be paying the same equivalent price which will make a total of approximately 80 cents per barrel for grades diverted to starch. This should be helpful in getting starch factories into operation generally, and help to stabilize the market here considerably.

Harvesting, in general, has not started in this area, as yet, but it is expected that next week practically every one will be digging. Yields are running somewhat better than expected around the central part of

Aroostook, but are lighter than expected south of Mars Hill and in the western section.

It also appears that yields on Katahdins will be about the same as last year but that Cobblers and Green Mountains will, in those areas where a more plentiful supply of moisture was received, be better than estimated on the first of September.

The quality of potatoes harvested to date seems to be excellent. The size is running somewhat larger than has been found in the past two seasons. Digging conditions are favorable for the growers now harvesting their early varieties.

There is some concern regarding the available supplies of labor but it is doubted if any acute shortage will develop.

Much grain remains to be threshed, although considerable progress is being made this week. Caring for the grain has been a more serious problem this year than usual because of the delay in ripening and also on account of unfavorable weather. Many small size combines are in operation this year. There has been a rapid growth of interest in this type of machine.

It is expected that there will be approximately twenty-six thousand acres of certified seed approved by the State Department this year. Some Bacterial Wilt is showing up in the Katahdin variety but the majority of the acreage entered for certification, in that variety, is clean. There is little evidence of it in other varieties here. Regulations are very stringent in that type of disease. The presence of one diseased tuber is sufficient to reject an entire field.

We are earnestly hoping that another Marketing Study will be made this year on Maine potatoes with New York as the base for operations. Such a project has not been approved as yet but definite decision is expected in the early future. (Sept. 14).—FRANK W. HUSSEY.

MICHIGAN

Several county potato grower tours have been held this year, all of which were well attended. Both fields of seed and table stock were visited. The interest shown by table stock growers in the production and use of certified seed was greatly noticeable.

Harvesting is beginning in a small way, and should be well under way by the 25th. Growing conditions have been generally good throughout the growing season. During August we had the greatest rainfall ever recorded in Michigan.

Late blight has been reported in several sections of the state, mostly

in fields of wet soil where no spraying program has been conducted. More new spring equipment has been sold this year than has been sold in many previous years. Our dealers have reported increased sales of copper sulphate and lime above that of last year. „

The Michigan Potato Growers' Exchange just completed its 22d year of operation. Its Annual Meeting was held on the 28th and 29th of August. The large attendance of delegates and visitors spoke well for the success of this organization. (Sept. 10).—H. A. REILEY.

NEBRASKA

The second inspection on certified potato fields in Nebraska was completed on all irrigated lots by the first of September. Dry land fields will be covered before the 15th of September, and a complete third inspection on irrigated lots will be made before the inspection is over. This last inspection is made primarily for a check-up on the presence of Ring Rot. Nebraska lots, in 1939, showed a very small percentage of this disease. The certified grower has had most difficulty with contamination from commercial non-certified lots, where potatoes are stored in cellars practicing custom storage. Every effort is being made to show the grower the necessity of extreme care in this matter of complete isolation to prevent contamination.

Considerable trouble is anticipated with stem end discoloration in the bin, caused by Fusarium Wilt that has been appearing during the last month. This difficulty is common in Nebraska, and all evidence to date is that it will be quite bad in many areas. Rejection for this trouble at the time of bin inspection causes heavy losses to growers of certified potatoes.

The condition of the crop from the standpoint of moisture is very spotted. Some excellent rains have occurred in parts of the dry land areas, but most yields are expected to range from 40 to 75 bushels per acre. Some territories at present have conditions which will produce 100 to 125 bushels per acre on the dry land, but this is true only of small areas. Cool weather has prevailed as a whole, but for the past week, it has been extremely hot for the time of year,—temperatures reaching 90° to 95° F. each day. This heat has caused considerable tip burn to the succulent plant growth, which developed during the cool weather previous.

The irrigated fields have progressed better than was expected a month ago. Some additional water was available in districts expected to be completely out by the middle of August. Most of the large irriga-

tion ditches went dry the first of September. This will probably raise the estimated yield of 50 to 60 per cent, as reported a month ago, to perhaps 75 per cent of the 1939 crop.

One other factor will influence the prediction just made. This factor is Early Blight, which has been progressing slowly, but steadily, for the past two weeks. At this writing, skies are overcast, and it is drizzling, which condition, if it continues for two or three days, will be ideal for an epidemic of early blight. In 1938, the epidemic set in almost this same time of the year, and by the 15th of September, most of the irrigated fields were completely matured. This is a loss from two standpoints, namely, early maturity, and the possibility of tuber rotting in the bin.

Harvesting activities on the early crop in western Nebraska have begun in a small way. A few shipments have already gone out. Prices are not very satisfactory at this time, ranging from 60 to 80 cents f.o.b. to the grower, depending upon the quality of the crop. A few of these shipments are going out by rail, but the bulk is moving by truck at the present time. The main harvest usually gets under way shortly after the first of October.

It appears that the quality of table and seed potatoes from a type and color standpoint, will be excellent. For this reason, dealers and shippers are planning to make a good showing in the washed table market, following successes of this past season. A strong campaign for the reduction of harvesting losses, because of mechanical injury and other preventable factors, is being conducted by the Nebraska Potato Improvement Association in cooperation with the Extension Service, County Agricultural Agents, dealers, growers and others interested in the industry. This campaign is being waged by many means, including newspaper articles, direct correspondence, radio appeals, harvesting demonstrations, and personal contact with growers. The Bliss Triumph variety, being very subject to mechanical injury, must be handled with special precautions to prevent excessive damage. In past seasons, it was not at all uncommon to have mechanical injury affecting one-third to one-half of the crop, reducing potatoes which otherwise would be U. S. No. 1, to culls, or even poorer. In contrast, many growers, during the past few years, have been able to store their potatoes in the cellar with only five to ten per cent mechanical injury. (Sept. 12).—MARX KOEHNKE.

OHIO

Potato harvesting has been a week to ten days later than normal. The Cobbler crop has practically been harvested and growers are now harvesting Chippewa and some Katahdins. Our yields are below those of last year and are running 200 to 250 bushels per acre. The set, in general, was heavy, but the hot dry weather in July was responsible for the reduction of the size of the tubers.

The late crop was planted late because of the early wet weather and made little growth until the rains and cooler weather came about two weeks ago. The late crop will need several weeks of good growing weather if yields of any size are to be expected. The frosts that have been prevalent this week have killed the vines in the muck area around Willard.

The new marketing program for potatoes in Ohio is under way and large quantities of potatoes are being moved in peck bags. The red label bags have been moving in the largest quantities. These are straight U. S. No. 1 grade. Some washed potatoes have been moving under the blue label, which is U. S. No. 1, size A. The prices on pecks are varying from 20 to 23 cents in the various markets. (Sept. 14).—E. B. Tussing.

NEW YORK

Record low temperatures accompanied by killing frosts, occurred quite generally throughout New York, with the exception of Long Island, on the night of August 25th. Late-planted potatoes in succulent condition were injured in varying degrees. In a few cases ,the crop was ruined by a complete killing of the plants before the tubers had reached marketable size. This was most true in the foothill sections of the Adirondack Mountains and along the Mohawk River Valley. Throughout most of the state, drought since early August has done more to curtail crop prospects than either frost or late blight. An excellent crop is being harvested on the muck areas and on Long Island. Prospects for blight injury in New York are reduced considerably from that reported on the 10th of August because of the recent drought. General rains over Central New York on the 9th and 10th of September will stimulate late growth and increase the average total yield but may not appreciably increase the marketable crop.

Digging demonstrations are to be held in ten counties during the period from the 18th of September to the 3d of October. The purpose

of these is to show, by actual operation how the various makes and types of diggers can be operated in order to result in a minimum of mechanical injury to the tubers and wear and tear on the machine. (Sept. 10). —E. V. HARDENBURG.

More leaf roll and yellow dwarf have been seen this year than usual. The situation in seed stock is not serious, however, because the Florida test enabled many seed growers to clean house. Yellow dwarf plants have made more than the usual amount of growth because of the cool season and the symptoms are milder and later. Very little new infection has been found. Late blight was observed early but has caused damage only locally, having been checked by dry weather. It is generally present, however. Potatoes planted in fields in the lower elevations of many valleys were killed by frost on the 24th of August. This will cause some loss in yield but will also check late blight and the spread of virus diseases. (Sept. 16).—K. H. FERNOW.

PENNSYLVANIA

We have approximately 1850 acres of potatoes entered for seed certification this year compared with 1208 acres entered in 1939. The principal varieties entered are the Russet Rural, Katahdin, White Rural, and Nittany Cobbler. Other varieties entered are Chippewa, Houma, and Green Mountain.

The first inspection has been completed with approximately 1,000 acres certified and more than 800 acres rejected. Inspections have been made under conditions that were quite favorable for the identification of diseases. Although we had a short period of dry hot weather most of the inspections were made during a period when moisture and temperature conditions were quite favorable.

Late Blight has appeared in our fields and has caused some damage. Frosts in some of the mountain counties during the latter part of August has killed several fields of potatoes entirely.

The late crop is developing nicely although we have had considerable cloudy weather accompanied by ample rainfall. (Sept. 13).—K. W. LAUER.

OREGON

Potatoes in the Klamath basin are being harvested earlier this year than normally. Our shipments will reach six to seven cars daily by the 1st of September. Both the quality and yields are about average. The acreage is slightly larger than that of last year.

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Since our crops are maturing earlier than usual the September shipments should be quite heavy. The third field inspection on certified seed is now being completed. Considerable leaf roll has been reported in certain districts, which has caused a number of fields to be rejected.

The early rains during the first week of September interrupted our harvesting operations. (Sept. 9).—C. A. HENDERSON.

RHODE ISLAND

The potato crop in Rhode Island is turning out very satisfactorily in spite of an extremely dry August. The growing conditions were ideal until August throughout most of the state. Commercial growers are reporting from 350 to 400 bushels yield of Cobblers. The Green Mountain crop will be fully as good. Chippewas are irregular—some very good yields, and some very poor because of excessive leaf roll. Sebagos are still growing and promise excellent yields in the co-operative tests as well as on two farms in commercial acreage. There is very little blight this year on any of the varieties that have been well sprayed. The price quotations range from $1.00 to $1.25 *per cwt.* depending on the variety and quality. (Sept. 16).—T. E. ODLAND.

SOUTH DAKOTA

Potato harvesting is now taking place in South Dakota with several cars being prepared for shipment to Cuba. Digging will be general by the 16th of September. The crop is spotted and yields will range from 75 bushels to 200 bushels per acre. Some sprouting in the ground has been found in Early Triumph fields but this condition is not expected to be serious. The bulk of the certified seed, of which there are more than 1,700 acres, will be stored for shipment in January. The Bliss Triumph will yield very good seed sizes this year, and the quality of the crop will be excellent. Our commercial crop in South Dakota consists mostly of Early Ohio and these will move mostly by trucks within the state. The surplus potato-producing area in South Dakota is located in five counties tributary to Watertown in the northeastern part of the state. Small farm plots of potatoes ouside the potato area will yield very little, if at all, because of insect damage and dry weather. (Sept. 10).—JOHN NOONAN.

ANNUAL MEETING

Philadelphia—Monday, December 30 to Wednesday, January 1.
Headquarters—Hotel Normandie.
All titles of papers must be in the Secretary's hands by November 1.

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COOKING-QUALITY PREFERENCES FOR POTATOES

ALIDA HOTCHKISS,[1] MARION WOOD,[2] AND PAUL FINDLEN[3]

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Competition of potatoes from other sections of the country with upstate New York potatoes has been increasing for a number of years. In 1935, a long time research program to study various problems of the potato industry was proposed by the Empire State Potato Club, and was subsequently undertaken by several departments of the New York State Colleges of Home Economics and Agriculture.

Some of the marketing problems called for facts on: (1) consumers' practices and preferences in buying and using potatoes; (2) retailers' practices and preferences in buying and selling potatoes; (3) preferences and practices of institution buyers; and (4) cooking quality and waste in preparation. Therefore studies have been conducted in Cleveland, Ohio, and in Rochester, New York, for the most part, during three seasons, 1936-'37 to 1938-'39.

Consumers were observed buying potatoes in retail stores in Cleveland and Rochester and later interviewed in their homes by members of the Department of Economics of the Household and Household Management; retailers in Cleveland and Rochester were interviewed by members of the Department of Agricultural Economics and Farm Management; institution buyers in Cleveland, Rochester, and New York

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TABLE 1.—*Consumers' statements of cooking qualities desired in potatoes*
Cleveland, October-December 1936, and Rochester, January-February 1937

Qualities Desired in Potatoes	Baking		Boiling		Mashing	
	Cleveland October-December 1936	Rochester January-February 1937	Cleveland October-December 1936	Rochester January-February 1937	Cleveland October-December 1936	Rochester January-February 1937
(Number of Consumers)	(553)	(276)	(598)	(303)	(570)	(272)
			Per cent of consumers			
Mealy, dry, fluffy, flaky	86	99	82	77	93	93
White, not turn dark	22	27	24	49	21	45
Solid, firm, keeps shape	3	3	23	32	12	14
Cooks evenly	3	4	2	3	9	8
Not too mealy	1	1	2	2	1	—
Moist	4	4	1	2	2	3
Good flavor	6	4	2	2	2	1
Cooks quickly	—	—	2	—	—	—

City were interviewed and the cooking quality tests were made by members of the Department of Institution Management.

This report summarizes only the information regarding cooking-quality preferences.

Consumers' Statements of Cooking Qualities Preferred

In 1032 home interviews, homemakers stated the cooking qualities that they considered most important in potatoes for baking, for boiling, and for mashing.

Mealiness was the quality desired by the greatest number of household buyers, for all methods of cooking, and was mentioned by more than three-fourths of the homemakers, as revealed in table 1. Next in preference whiteness was apparently the quality for all three methods of cooking. A potato that would hold its shape and not slough off in the cooking was desired for boiling.

A noticeably higher percentage of Rochester than of Cleveland homemakers preferred whiteness in potatoes to be boiled or mashed; possibly their experience with potatoes in this market during the 1936-'37 season had been such as to emphasize whiteness in the cooked product.

Consumers' Statements of Dissatisfaction with Potatoes Bought

These homemakers were also asked whether they were satisfied with the potatoes that they had bought at the time when an enumerator had observed them in the retail store. Only a small proportion of the consumers expressed dissatisfaction with these potatoes as shown in table 2. However relatively more consumers in both markets were dissatisfied with the potatoes for boiling than for any other method of cooking, and in Rochester a considerable number were disssatisfied with the potatoes when baked. Moreover, more consumers in Rochester than in Cleveland were dissatisfied with their potatoes. In general, relatively more consumers were dissatisfied with the potatoes bought during the period of the study in 1937-'38 than in 1936-'37. The results of cooking-quality tests at the College on samples identical to those bought by consumers indicated that in 1937-'38 the potatoes were less acceptable from the standpoint of appearance when cooked, but tended to have a slightly more desirable texture.

When the consumers who were dissatisfied with the potatoes were asked the reason for their dissatisfaction, the outstanding reason in Rochester was the fact that they turned dark or black (table 3). Cooking to pieces, or becoming mushy, as well as turning black, was one of the main causes of dissatisfaction in Cleveland.

Even though most homemakers said that they were satisfied with the potatoes they had bought, cooking tests at the College of the same potatoes that these consumers had bought, indicated that many samples did not possess the qualities that homemakers stated they preferred in potatoes. This lack of agreement between preferences and satisfaction may be accounted for by several factors: (1) consumers undoubtedly stated preferences without regard to the price that would be necessary to obtain such qualities; but when reporting whether they were satisfied with the particular sample bought, they probably considered quality in relation to the price that they had paid; (2) since consumers tend to buy potatoes frequently and in small amounts, an individual purchase may not have been judged as critically as though a larger expenditure of money had been made; (3) in cooking, poor

TABLE 2.—*Percentage of consumers stating dissatisfaction with the potatoes bought when observed, according to method of cooking*

Cleveland, October-December 1936 and 1937, and Rochester, January-February 1937 and 1938

Method of Cooking	Number of Consumers Who Cooked the Potatoes in Each Way				Per cent of Consumers Who Considered the Potatoes Unsatisfactory for the Particular Method of Cooking			
	Cleveland October-December		Rochester January-February		Cleveland October-December		Rochester January-February	
	1936	1937	1937	1938	1936	1937	1937	1938
Mashed	429	406	252	230	5	8	7	11
Boiled, peeled	321	241	182	165	10	15	19	24
Baked	259	212	142	118	2	1	13	12
Fried	181	158	96	98	3	2	6	4
Scalloped	123	78	76	64	2	—	7	2
Creamed	42	26	40	40	5	8	5	3

TABLE 3—*Consumers' reasons for dissatisfaction with cooking qualities of potatoes bought when observed*

Cleveland, October-December 1936 and 1937, and Rochester, January-February 1937 and 1938

Reasons for Dissatisfaction	Number of Times Stated				Per Cent			
	Cleveland October-December		Rochester January-February		Cleveland October-December		Rochester January-February	
	1936	1937	1937	1938	1936	1937	1937	1938
Turned dark or black	17	13	48	41	26	17	58	48
Cooked to pieces, became mushy	20	22	6	14	30	30	7	17
Soggy, not mealy	9	2	8	11	14	3	10	13
Watery	8	18	3	1	12	24	4	1
Lumpy, too long to cook, hard centers	4	12	11	12	6	16	13	14
Yellow, not white	2	—	4	2	3	—	5	2
Sticky, gummy, rubbery	3	1	—	—	5	1	—	—
Too mealy, dried out	2	4	1	1	3	5	1	1
Not good flavor	—	3	2	3	—	4	2	4
Not attractive	1	—	—	—	1	—	—	—
Total	66	75	83	85	100	100	100	100

potatoes may have been improved by the use of butter, milk, or gravy, or by mashing or creaming; (4) consumers apparently buy potatoes from few sources only, thus they may tend to be satisfied with whatever their retailers offer rather than shopping around for a better quality of that one product; and (5) consumers who had purchased and used a product not be extremely critical of it unless it had been unusable.

RETAILERS' STATEMENT OF CONSUMERS' COMPLAINTS

In obtaining information on retailers' demand and preferences for potatoes, retailers were asked the question, "What complaints have consumers made about potatoes?" While it was not feasible to find out how many consumers complained to retailers, it was possible to determine the nature of consumers' complaints. More than one-half of the retailers in both cities reported complaints regarding potatoes.

In Cleveland and in Rochester, for each of the years studied, unsatisfactory interior quality of the cooked potatoes was the outstanding

TABLE 4—*Retailers' statements of consumers' complaints about potatoes*

Cleveland and Rochester, 1935-'36 to 1938-'39 seasons

Most Common Complaint	Per Cent of Stores						
	1935-'36	1936-'37		1937-'38		1938-'39	
	Cleveland	Cleveland	Rochester	Cleveland	Rochester	Cleveland	Rochester
Cooked black	43	47	40	57	38	56	32
Other cooking faults	16	12	13	6	4	10	6
Insect injury	8	16	16	6	22	7	3
Other defects	28	20	17	25	26	26	58
Size	5	5	14	6	10	1	1
Total	100	100	100	100	100	100	100
Number of stores reporting complaints	166	135	101	117	137	108	116
Per cent of stores reporting complaints	79	65	55	51	63	62	67

complaint that consumers made as reported by retailers as is shown in table 4. Cooking black was the most common complaint as reported by one-third to nearly three-fifths of the retailers reporting complaints. Relatively more stores in high-income areas had complaints than did stores in low-income areas. Furthermore, relatively more stores in the high-income areas reported complaints relating to cooking quality than did stores in the low-income areas.

Institution Buyers' Statements of Cooking Qualities Preferred

Institution buyers interviewed in New York City, Rochester, and Cleveland, in stating their preferences, were concerned chiefly with the palatability of the cooked potatoes. Requirements for acceptable institution use were: in cooking quality, (1) mealiness, and (2) good color with no objectionable darkening on cooking and holding for serving; in regard to other qualities, (1) uniformity in size of tubers for standardized servings, (2) specific size range for certain purposes such as French frying, baking, and steaming, and (3) reasonably perfect tubers with respect to shape and defects.

Cooking Qualities of Market Samples

The samples of potatoes purchased in retail stores in Rochester and Cleveland were sent to the College to be cooked and scored for the three qualities, appearance, texture, and flavor; individual ratings for these qualities ranged from *very good* to *very poor*.

These cooking tests indicated that there was wide variation in cooking quality within individual varieties grown in Maine, New York, or Ohio.

Darkening was the most important factor in rating appearance. Additional factors considered were: sloughing or scaling off of the outer layer of steamed and boiled potatoes; surface dark spots as differentiated from general darkening; and general color. Steamed potatoes, even though suitable with respect to the other factors mentioned, tended to be less acceptable as darkening increased as revealed in table 5.

As to texture, steamed potatoes that were reasonably mealy were considered good, whereas those baked were more desirable if their texture was very mealy. Soggy potatoes, in general, were rated as unacceptable for both steaming and baking as you will note in table 6.

Flavor was seemingly the least important of the three qualities, since it was easily improved by varying the methods of cooking and adding seasonings.

TABLE 5—*Degree of darkening and appearance ratings of steamed potatoes*

Cleveland, October-December 1937 and 1938, and Rochester, January-February 1938-1939

Degree of Darkening	Number of Judgments*	Appearance Rating		
		Very Good and Good	Fair	Poor and Very Poor
		Per Cent of Judgments		
No darkening	66	94	6	—
Slight darkening	70	80	19	1
Moderate darkening	12	—	50	50
All judgments	148	80	15	5

*One judgment on each sample.

SUMMARY AND CONCLUSIONS

Mealiness and whiteness were the cooking qualities considered most desirable by both household and institution buyers. As to their relative importance, mealiness was more often mentioned by the homemakers than whiteness as preferred in potatoes, although turning black seemed to be the cause of more dissatisfaction than sogginess. Then, too, more retailers reported complaints of consumers about potatoes cooking black than about any other factor, although the number of consumers making such complaints was not obtained. The general preferences of both homemakers and institution buyers were supported by the judges in rating cooking quality of market samples of potatoes. It is clearly evident that mealiness and whiteness were the two most important characteristics in the cooked product. Consumers would undoubtedly welcome potatoes that could be depended upon to cook white and be mealy, provided that in producing potatoes having such characteristics, other desirable qualities were not sacrificed nor the price made prohibitive.

Statements by homemakers or other buyers pertaining to the qualities or characteristics they prefer in potatoes, or in other products, are useful as indicating the standards by which consumers judge the goods

they buy. Unless accompanied by a willingness to pay a price, however, they mean little in the way of market demand. In other words, it is useful to know what kinds of potatoes consumers prefer, but it is of equal importance to determine also preferences in terms of the buying practices of consumers. Therefore, even though statements of preferences do not measure effective market demand, such facts are of use to producers and to research workers who are interested in the improvement of potatoes.

TABLE 6—*Degree of mealiness and texture ratings of steamed and baked potatoes*

Cleveland, October-December 1937 and 1938, and Rochester, January-February 1938 and 1939

Degree of Mealiness	Number of Judgments*	Texture Rating			
		Very Good	Good	Fair	Poor and Very Poor
			Steamed		
Mealy and dry	279	49	42	8	1
Mealy	765	5	73	20	2
Mealy and wet	425	—	8	77	15
Soggy and slightly mealy	201	—	—	27	73
Soggy	142	—	—	8	92
All judgments	1812	10	39	31	20
			Baked		
Mealy and dry	210	61	32	5	2
Mealy	591	9	68	22	1
Mealy and wet	447	—	10	74	16
Soggy and slightly mealy	263	—	1	25	74
Soggy	131	—	1	4	95
All judgments	1642	11	31	33	25

*Three judgments on each sample.

POTATO FERTILIZER AND NUTRITION STUDIES IN 1939[1]

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Results of investigations published in 1939 and the latter part of 1938 on fertilizers, fertilization, green manures, cover crops, rotations, soil fertility, soil reaction and sand and solution culture studies with the potato are summarized briefly in this report. The material on these subjects is not claimed to be complete. Most of the titles in a foreign language are translated. Some references which have not been abstracted in this review are included in the bibliography with the literature citations for the benefit of those desiring a fairly complete bibliography on this subject.

In a series of experiments in Alabama over a period of 8 years Ware (78) arrived at the following conclusions: 90 lbs. of potash per acre should be adequate on many soils although it may be advisable to apply 120 lbs.; not less than 135 lbs. nitrogen per acre should be supplied to potatoes grown on new soil the first year after clearing. After the first year and for several years thereafter it appears that potatoes grown on new ground should receive 90 lbs. of N. per acre. On old land with no legumes in the rotation 60 lbs. of N. per acre will be adequate on most soils. After several years of legumes in the rotation N may be reduced to 45 lbs. per acre. Phosphoric acid is recommended at the rate of 150 lbs. per acre.

Grantham, Miller and Mick (29) report the following results from experiments in Michigan: Manure supplemented with complete commercial fertilizer, 4-16-8 or similar analysis, is an excellent fertilizer for potatoes. A fertilizer of 4-16-8 or similar composition gave increases in yield which were consistently among the highest produced by the different fertilizer analyses used in the tests on different soil types and under the varied weather conditions encountered during the 15 years covered by the experiments. A fertilizer containing more potash in relation to the phosphoric acid as a 3-12-12 frequently gave as good yields or even better than the 4-16-8, especially on the sandier soils. Fertilizer containing as much or more potash than P_2O_5 tended to delay maturity. Fertilizer applications of 500-600 lbs. per acre were found

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most advisable although larger yields were frequently obtained with heavier applications. Under irrigation heavier applications of fertilizer were efficiently used. Fertilizer placed in bands on both sides of the seed piece on the level with or a little deeper than the seed and about two inches from it has given slightly better average yields than the same quantity of fertilizer applied in other locations. In a review of fertilizers for potatoes in Southern New England Brown (6) summarizes as follows: it appears that 100 lbs. N per acre is sufficient under practically any conditions, that 80 lbs. is ample in many cases and that in a rotation where a sod crop precedes potatoes, 60 lbs. or even less will give maximum yields. Seldom do potatoes respond to more than 160 lbs. phosphoric acid and 120 lbs. or even less will give optimum results under continuous culture or in short rotations. There is a general maximum need for 100 lbs, N, 160 lbs. P_2O_5 and 140 lbs. K_2O per acre for potatoes in this area. This is equivalent to one ton 5-8-7. When a sod crop precedes potatoes the N may be safely reduced to 60 lbs. Under continuous or nearly continuous potato cropping, P_2O_5 can be reduced to 120 lbs. or even less. The potash also can be decreased on previously well fertilized soils but not as much as the P_2O_5. In most cases 120 lbs. of K_2O will be adequate. Where the pH is above 5.5 lime should not be used except in long rotations. It is very doubtful if there will be any need for magnesia, but if used, 20 lbs. are sufficient. This can be supplied by 125 lbs. $MgSO_4$ or 70 lbs. of kieserite. There is no evidence indicating that these soils do not supply the minor elements in adequate amounts for potatoes.

Ruprecht and Winsor (61) conclude the following from fertilizer experiments conducted in the Hastings, Florida area: synthetic calcium bearing nitrogenous materials under properly regulated conditions produced excellent yields. Phosphoric acid at the 2 per cent level in the formula may be too low for long continued use or for conditions of optimum moisture, but through the period studied (1933-'37) produced very good results. Higher than 2000 lbs. per acre of mixed goods proved uneconomic either as an initial application or as a total application. Trace elements applied as side dressing gave no increase in yields. Increasing the 6 per cent potash content of a formula to 8 or 10 per cent did not increase the yields. Prince (56) concludes from experiments in New Hampshire that a 1-2½-2½ or a 1-3-3 ratio is best especially for the system of long rotation farming which is practiced a great deal in New England. Most farmers can afford to apply a little more than a ton of fertilizer per acre, especially if they are commercial growers and

using no manure. Bushnell (9) reported that in Ohio for an average of 5 years the effect of 1500 lbs. of 4-10-6 fertilizer applied two inches to the side of the seed piece was an increase of only 15 bushels per acre over unfertilized plots. Lyons (46) reporting on some fertilizer experiments in Western Nebraska states that 100 lbs. 43 per cent superphosphate increased yields over unfertilized 35 bushels per acre; 200 lbs. ammonium sulfate increased 41 bushels; 300 lbs. ammonium sulfate 36 bushels and 200 lbs. ammonium sulfate plus 100 lbs. 43 per cent superphosphate increased yields 54 bushels per acre compared with the unfertilized.

Depardon (20) found by a comparative study of the soil in three regions of France that the soil was the dominant factor in influencing composition of the potato plant and that climatic factors accentuate the soil effects. Soils which retain moisture promoted leafiness. Soils low in phosphorus, calcium or magnesium produce plants low in these elements. Joret and Malterre (39) found that in a soil in France containing 330 parts of $CaCO_3$ per 1000, 3.1 parts of N, 3.57 parts of assimilable P_2O_5 and 0.25 part of assimilable K_2O per 1000, P_2O_5 fertilizers played only a very secondary rôle in potato yields. The fertilizer selected for such soil was a 1-0.5-2, ⅔ of its N as ammonium and ⅓ as nitrate.

Martin and Liwerant (48) state that a 1-1.2-3 fertilizer was best for potatoes on alluvion soil of Garonne, France. The suppression of chemical fertilizers caused a marked decrease in yields. Wallace and Thompson (77) recommend for maincrop potatoes on silt soil in England a mixture containing about 7 per cent N, 6.2 per cent phosphoric acid and 11 per cent potash at the rate of 1350-1500 lbs. per acre. Morton (51) reports that on fen soils in England where manure had been applied but no commercial fertilizer the yield was 11.45 tons per acre, where 1200 lbs. superphosphate and 300 lbs. sulfate of ammonia were applied in addition to the manure the yield was 16.94 tons per acre. On a deep silt soil where no farm-yard manure was used, with no commercial fertilizer the yield was 9.84 tons; with applications of 250 lbs. sulfate of ammonia, 1100 lbs. 30 per cent superphosphate and 400 lbs. potassium sulfate per acre the yield was 14.34 tons per acre. Hanley (30) has presented a review of work in England on quantities of manure most profitable to apply, methods and time of application, supplemented with commercial fertilizers, application of N, P and K and their interactions on the size and yields of potatoes.

Mattingley (49) reported fertilizer test results in various parts of

Victoria. The 1938-'39 growing season was so dry, however, that all yields were very low and differences between most manurial treatments were trivial. Ramsay (58) reports that ammonium sulfate in conjunction with superphosphate is the most beneficial and profitable manurial treatment for potatoes grown in Victoria. The quantities per acre of superphosphate giving maximum yields varies from 300 to 900 lbs. From 8 locations four show a definite decrease in yield where 200 lbs. per acre ammonium sulfate is applied, two others show no profitable increase, whereas two show definite increases. Ramsay (59) states that the only elements necessary to add to soils used for potato growing in Victoria are N, P and K. The most important is phosphorus, Victorian soils being markedly deficient in this element. Next in order of importance is nitrogen, while potash is of least consequence. The best form in which to apply phosphoric acid is as superphosphate and the best source of N is ammonium sulfate. With one or two exceptions potash has not increased potato yields. KCl appears to lower cooking quality whereas K_2SO_4 will improve it. Singh and Mehta (68) found that with N, P and K fertilizers applied singly and in combinations, N increased the yield and size of tubers, whereas K had no appreciable effect. A direct relation existed between high yield and the proportion of large tubers. Schmitt (63) investigated the effects of complete fertilization with varying admixtures of dicyanodiamide from 1 to 20 per cent in the fertilizer on eight different soil types. No injury resulting from the use of this compound and no apparent effect on nitrogen assimilation by potatoes were noted. Schmitt (64) showed with extensive experiments, using eight different types of soil over a period of two years that even fairly high dicyanodiamide concentration in the $CaCN_2$ fertilizer caused no injury to the plants. Only with the addition of 10 per cent or more dicyanodiamide N was there a reduction in the crop and injury to the plants. In laboratory and field experiments even a beneficial effect of increasing doses of dicyanodiamide could be observed. The use of crude calcium cyanamide which contains at most 1.5 per cent dicyanodiamide nitrogen can therefore be in no wise injurious.

Kruger, Roemer, Wimmer and Ludecke (42) describe field experiments in Germany which have been conducted since 1909 with varying rotation and fertilization treatments. Potato yields during a 20-year period show a decrease from 203 to 143 bushels per acre without fertilization. Constant yields were obtained by fertilization with phosphorus and potassium, whereas a moderate decrease in yield resulted when the potatoes were fertilized with nitrogen, phosphorus or potash alone. Obtaining large potato crops depends on artificial irrigation

and the use of mineral improvers according to Chetkin (10). Artificial gasing with CO_2 also gave good results. By these means the yield can be increased 89 per cent to 104 per cent. As determined by analyses and by field tests with potatoes Gliemeroth (28) found that the loss of nutrients from manure and litter was least with the peat litter.

Bushnell (8) has indicated that the system of growing potatoes year after year on the same field is going to require more fertilizer than the old system of rotation. With the dropping out of legumes from the rotation there is likely to be a need for applying some nitrogen fertilizer after the plants appear above ground. Ammophos and urea have been sufficiently tested to be recommended as substitutes for the old standard materials providing the price is lower. Depardon (17) concluded from experiments in France that the starch content of potatoes grown in Perche was not influenced by the additions of nitrogen fertilizer whereas the nitrogen additions depressed the starch content of potatoes raised in Sologne. $CaCN_2$, NH_4NO_3, $Ca(NO_3)_2$ and $(NH_4)_2SO_4$ were compared as sources of nitrogen. In the first locality $CaCN_2$ gave the greatest yield increases while in the second the ammonia N gave the best yields. Dopter (21) also working in France, found that the use of large amounts of N, particularly in dry years, gave improved yields of potatoes. The N content of the potatoes was increased by the N additions. Large doses of N caused a decrease in the dry matter content of the tubers.

Joret and Malterre (40) conclude from experiments in France that no benefit in the cultivation of potatoes can be derived from the addition of P_2O_5 to chalky or lime soil containing approximately 1.5 parts per 1000 of available P_2O_5. The addition of P_2O_5 may even have an injurious effect on the yields. Ammonium phosphate gave the same results as a mixture of superphosphate and $(NH_4)_2SO_4$ in the cultivation of potatoes on this chalky soil. Preliminary experiments by Herisson-Laparre (35) show that the use of superphosphate is effective in combating brownspot in potatoes. The beneficial effect is due to the P_2O_5.

Boischot and Drouineau (4) recommend that when K_2O is used in calcareous clay soils for potatoes it should be turned under so as to be readily available to the plant. The nutrient shows little migration in this type of soil. Under these conditions the fertilizer should be high in K_2O. The use of a fertilizer lacking either N, K_2O, or P_2O_5 is an expensive practice and may even exert a slight depressive effect on the yield. Brioux and Jouis (5) applied 150 kilograms of K_2O per hectare to potatoes which had already received about 28,000 kgms. of manure per hectare and obtained no greater increases in yields than from applications of

75 kgms. The K_2O increased the amount of the K_2O in the tubers. Depardon (18) reports from experiments in Perche and Sologne, France showing that the use of K_2O fertilizer increased the K_2O content of the potato yield and had practically no effect on the starch content. Vincent *et al* (76) have shown that the end of February is the best time for applying K_2O to these soils in France for potatoes. During a period of 4 years, in spite of the addition of K_2O to these soils, the assimilable K_2O content of the soil has dropped from 0.386 to 0.108 per 1000. In the check plot the assimilable K_2O dropped to 0.015 per 1000. This K_2O deficiency has a very marked effect on the composition of the plant. High yields can be obtained on these K_2O deficient soils only through the annual addition of a minimum of 100 to 150 kg. of K_2O per hectare. Lefort (44) obtained the largest increases in yields of potatoes by the use of K_2SO_4 when the sulfate was added before planting. Joret and Malterre (41) report that the use of a 1.0-0.63-2.2 fertilizer on soil containing 328 parts per 1000 of $CaCO_3$, 127 colloids and 0.11 of available K_2O caused large increases in potato yields. KCl was superior to KNO_3 as a source of K_2O.

Jacob (37) reported that a sandy soil cropped for 6 years to cereal, legumes, beets and potatoes indicated that the removal of K_2O by cropping was accurately reflected by Neubauer tests down to the point where the latter indicated exhaustion of the available K_2O. Beyond that point crops were still able to secure K_2O but yields were reduced and there were marked symptoms of deficiency. Cowie (14) reports that in experiments on acid sandy soils of low fertility, marked symptoms of K deficiency were frequently observed on plants which received applications of N and P but no K, whereas these symptoms were not observed on plants which received either N, P and K or only N. Of potatoes inoculated with wart disease planted in plots treated with KCl, 190 kg. per hectare, and K_2SO_4, 215 kg. per hectare, Leszczenko and Szymanski (45) found only 59.1 and 72.7 per cent respectively developed the disease compared with 95.4 per cent in control plots. Other K salts reduced the proportion of diseased tubers also but not so greatly. KNO_3 however, showed 100 per cent infection. When double the amount of fertilizer was used infection increased except a small decrease with KCl and potassium phosphate. Serdyukov (67) reports that it is advisable to apply potash after farm manure and before planting for best results.

Purvis and Blume (57) report that in Virginia maximum and equal yields of potatoes were obtained following (1) soy beans, (2) soy beans and sorghum, (3) sorghum and (4) sorghum plus 250 lbs. $NaNO_3$ or ammonium sulfate when plowed under. Fresh organic matter was

found to be approximately three times as effective in increasing yield as was residual organic matter. Baker and Klages (1) show that for a nine-year period, 1929 to 1937 inclusive in Idaho the following yields of potatoes per acre were obtained in various rotations: (1) following three years alfalfa, 202 cwt.; following three years alfalfa plus manure, 242 cwt.; following one year wheat and two years of peas, 171; same plus manure, 202; following three years red clover for seed, 187; same plus manure, 230; and following five years alfalfa, 250 cwt. the first year and 210 cwt. the second year.

Berkner (3) states that green manures are not so good for potatoes in eastern Germany. In a further study Berkner and Weise concluded that as legumes for green manures for potatoes crimson and white clovers are not in any respect inferior to lupines and in the utilization of nitrogen are superior. The nitrogen of a lupine crop plowed under is as good as that of stable manure. Horse beans are equal to lupines and there is no difference in the value of the bitter and non bitter varieties of lupines. Wessels and White-Stevens (79) tested nine different organic and inorganic sources of nitrogen and three mixtures of two or more of these sources for their effect on the yield of Irish Cobbler potatoes on Long Island. No significant differences in yield were obtained. In 1937 the largest yields of potatoes in an experiment comparing organic fertilizers with inorganic, by Vickers, Tinsley and Bryant (75) were obtained with complete inorganics, then shoddy plus inorganics, F.Y.M., dried poultry plus inorganics, hoof and horn plus inorganics, castor meal plus inorganics, dried poultry, castor meal, shoddy, no treatment, N only and hoof and horn in descending order.

Cumings and Houghland (16) have summarized the fertilizer placement for potatoes for the period 1931-'37 under various prevailing conditions in Aroostook County, Maine; Long Island, N. Y.; Central New Jersey; Eastern Shore of Virginia; Northeastern Ohio; and Western Michigan. Single and double strength fertilizers were applied at the usual rates per acre and in a range of rates in some cases. Placement of the fertilizer in a band immediately under or above or mixed with the soil around the seed piece usually resulted in delayed emergence of the sprout above ground and reduction in yield. Fertilizer placed in a band at each side of the row rather consistently produced the most rapid emergence of sprouts, the most vigorous plant growth and the highest yields of primes as well as total yields. Placement of fertilizer in a band at only one side of the row gave lower yields than a band at each side. Hill placement of fertilizer in short bands at each seed piece or hill gave no indication of advantage over comparable placements in con-

tinuous bands along the row, for seed spacings ranging from 12 to 16 inches. Houghland (36) reported on rate of emergence of potato sprouts under different methods of fertilizer application in Virginia and Maine. Fertilizer placed in bands at the side of the seed resulted in earlier emergence of sprouts than any other method of application. Brown *et al* (7) in an experiment in Virginia with separate fertilizer ingredients applied at various locations with respect to the seed piece, found that nitrogen when applied in the row retarded emergence and lowered yields more than either phosphorus or potash when applied in the row. The lowest yields were obtained when the nitrogen and potash materials were applied in the furrow and the superphosphate on each side; the highest when this procedure was reversed. The divided placement resulted in a yield increase of 27.5 bushels per acre above that of a complete fertilizer applied in a band on each side of the seed piece. Prince (55) showed that in a six-year test comparing 2000 lbs. 4-8-7 broadcast with application in the hill that the latter outyielded the former only 12 bushels per acre. Collins (12) has reviewed some of the literature on methods of fertilizer placement recommended for southern crops.

Smith and Nash (69) reported results of sand culture experiments relating the chemical composition and cooking quality of the tubers. The low calcium and low boron cultures were slower to come up than any others. Deficiency symptoms were observed in low magnesium, low potassium and low copper cultures.

In most instances the deficiency of an element caused increases in total sugars, starch, tyrosine and tryptophane. In most cases low or medium potash caused increases in starch, alpha amino nitrogen, tyrosine and tryptophane. Manganese deficiency caused reductions in total sugars and starch and increase in tyrosine. There were no consistent differences shown by the cooking tests. The only darkening after cooking was in a sample grown in a low potassium culture and the per cent of amino acids, particularly tyrosine and tryptophane, were higher in these samples. The per cent of starch and the protein-starch ratio apparently did not affect the mealiness of these potatoes. Teakle and Stewart (70) reported that copper additions were the primary cause of a 40 per cent increase in potato yields on an acid black muck (pH4.2) at Bornholm and a spectacular growth of oats following the potatoes. The copper gave a more vigorous foliage, a strong development of branches, a more profuse and prolonged flowering and super tubers. The tuber eyes were stronger and more deeply set and the effect was carried over to the succeeding crop. No observable effect was obtained from

additions of Mn, Zn, Fe, Co or B. Cu in combination with Mn and Zn was not superior to Cu alone.

Thomas (71) grew Russet Rural potatoes on plots treated with rotted horse manure and with complete commercial fertilizers differentially equilibrated. The intensity of nutrition and the composition of the mean NPK unit of the 4th leaf of potato plants growing in the manure plot are 10.35 and 65.0-5.72-29.3 respectively. This intensity and composition or the mean NPK unit are regarded as near the optimum for the potato in that particular year. Commercial fertilizer plots yielded less than the manure plot. This difference was correlated with a difference in foliar diagnosis. The N, P and K contents of leaves of the same physiological age sampled periodically from potato plants grown on plots receiving different fertilizer treatments were studied by Thomas and Mack (72) in relation to the nature of these treatments and to the development of the plants. The addition of each of the dominant nutrient elements to the soil increased the content of the element in the leaves sampled whether the element was applied alone or in combination with one or both of the other elements. Utilization of any nutrient, however, is greatly influenced by the presence of other nutrient elements in the fertilizer. The content of N in the leaves is not related to the development of the plants. Low P content and low utilization of this element are associated with unsatisfactory development. Equilibrium between N and P throughout the season and a maintained rapid utilization of K at a high level are associated with good development of the plant. Thomas and Mack (73) reporting further on foliar diagnosis as a method of arriving at a basis for fertilizer practice found that there is no direct relationship between the content of N in the leaf and the yields from different treatments, nor between the presence of this element in the fertilizer and the yield. A relationship exists between the content of phosphoric acid and also of K_2O in the leaf and the yields from the different treatments, but no relationship exists between their presence in the fertilizer and the yield. Thomas and Mack (74) further showed that the relative positions of the mean NPK unit of couplets indicate that in six high yielding couplets differing in yield by 12 per cent or less, the higher yielding duplicate has higher K_2O and lower N in the NPK unit and a higher intensity of nutrition. In four low yielding duplicates having large differences in yield between duplicates the higher yielding duplicate has higher N and lower K_2O in the NPK unit with lower intensity of nutrition or with intensities nearly identical.

Chucka and Brown (11) in reporting results of experiments in

Aroostook County, Maine for an eight-year period showed that an application of approximately 25 lbs. MgO per acre in the form of either Epsom salts, sulfate of potash-magnesia or calcined kieserite, was sufficient to take care of the Mg requirements of the potato crop. Dolomitic limestone, when mixed with the fertilizer, helped considerably but when there was a shortage of available Mg it was found that it was best to use a soluble source of Mg. Dolomitic limestone served its best purpose when it was applied broadcast to tone down soil acidity and help build up a reserve of Mg in the soil. When used in potato fertilizer, high Ca limestone nearly always depressed the yield. Although applications of soluble Mg salts to potatoes at the budding stage failed to impart a green color to foliage already chlorotic, they prevented new foliage from developing chlorosis. Significant increases in potato yields were obtained by adding $MgSO_4$ (60 lbs. total during the season) to the regular Bordeaux mixture sprays, particularly in potato fields where severe Mg deficiency symptoms occurred soon after the plants have emerged from the ground. There was evidence that Mg applied as a spray was absorbed, at least in part, directly by the foliage. Depardon (19) found that the use of MgO caused increased yields of potatoes. Joret and Malterre (38) in experiments conducted for eight years showed that the yearly additions of sulfur which increased potato yields at the beginning of the period did not give any increases in the last years. The use of S increases the N content in the dry material because of its influence on nitrification and the ammonization of the nitrogenous organic materials of the soil. Ruebenbauer (60) in Poland grew two varieties of potatoes Ackersegen, healthy, and Goldwahrung, infected, by virus diseases, on plots where oats and beets were previously grown. Mineral fertilization of the plots was employed before the potatoes were planted as follows: no fertilizer, NP, NPK, and NPKB. The fertilizers used were 60 kgms. K_2O in the form of a plain or borated K salt, 30 kgms. P_2O_5 in the form of superphosphate and 30 kgms. N per hectare in the form of $(NH_4)_2SO_4$. In all experiments boron had an evident effect on shortening of the vegetation period of potatoes. During this period no differences in the occurrence of virus diseases of potatoes in dependence on the kind of fertilization was observed. The yields of the infected variety Goldwahrung were lower on borated K salt than on plain. Parker (53) presents the results obtained by Carolus on the time and rate of absorption of plant food by potatoes in some experiments conducted in Virginia. Magrou (47) grew potatoes aseptically from seed with the aid of liquid media. In the presence of sunlight tubers were produced when the nutrient solution contained 0.4-6.0 per cent

of glucose or 0.4-4.0 per cent of glycerol but when the solution contained 7-8 per cent glucose only plants kept in the dark produced tubers.

From experiments in Wisconsin, Larson, Albert and Walker (43) report no reduction in scab by application of lime even in amounts beyond those which would be economically profitable. There also were no marked effects on yields from any of the treatments. Cook and Nugent (13) report from Virginia that the use of acid forming fertilizers may be advisable on soils where scab has been prevalent in sufficient amount to materially injure the quality of the crop, but their use will not prevent scab until they have lowered the reaction of the soil to at least pH 4.8. Eddins in Florida (22) found that a single sulfur-limestone treatment controlled brown rot four years in Scranton fine sand and three years in Bladen fine sandy loam. This treatment consisted of an application of 800 lbs. of sulfur per acre in the summer resulting in pH 3.8 to 3.9 followed by 3000 lbs. limestone per acre in the fall which restored the reaction to pH 5.3-5.8.

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REPORT OF COMMITTEE ON NOMENCLATURE

During the past year but very little new material requiring nomenclatural consideration has come before the Committee, therefore, this report is limited to the few miscellaneous items that have come to the attention of some of its members.

Instances have been reported to the chairman in which the name White Bliss has been applied to stock of Warba. White Bliss is considered synonymous with such well-known names of earlier days as Pride of the South, Noroton Beauty and Quick Lunch. Although the two varieties, last named, were claimed by their introducers to have been of seedling origin, the stocks of these varieties grown in recent years, as well as those designated as White Bliss and Pride of the South, have been found to be identical with known sports of Triumph. The occurrence of such sports has frequently been reported and they have undoubtedly been the source of stocks bearing the names mentioned above.

In general appearance the tubers of White Bliss and Warba correspond so closely that it is only by a careful comparison of certain characters that they can be distinguished. As a rule the tubers of Warba are a little more irregular in outline, a condition caused by a slight bulging below the eyes. The color of the skin of this variety is usually white, though occasionally pale pink

splashes are found, whereas the skin of White Bliss, when first dug, has a faint pinkish tinge. This color soon disappears in storage, so it is only in freshly-dug material that this character is of value for taxonomic purposes.

A fairly constant difference is found in the sprouts of the two varieties which have developed in the dark. In Warba the small protuberances on the body of sprouts ½ to ⅝ inch in length are white or nearly so, whereas in White Bliss they are distinctly colored.

These varieties, however, can be distinguished readily by their vine characters, since the vines of White Bliss are practically identical with those of Triumph, while the vines of Warba have but little resemblance to the Triumph type of vine.

Information has recently come to light which indicates that the variety commonly known as Spaulding Rose, or Spaulding No. 4, is identical with the old variety Pride of the West. From correspondence furnished the chairman, which has been confirmed by information secured by Dr. Hardenburg, it appears that Pride of the West was at one time extensively grown in Steuben County, New York. Mr. S. T. Spaulding of Avoca, New York, a shipper of seed stock to Florida, is said to have grown this variety and shipped it under the name of Spaulding No. 4.

The first published reference to Pride of the West which is known to the writer appeared in the annual catalog of Peter Henderson and Company in 1890. The brief description which is given corresponds to that of the Spaulding Rose. No data are given regarding its origin.

Dr. Hardenburg has pointed out that here and there throughout the East there are found, occasionally, some of the old varieties which have long since disappeared from commercial production, mentioning in particular two purple-skinned varieties, Blue Centennial and Blue Mercer.

The last-named variety is of special interest because of its relationship to one of the most important varieties of a century ago; *viz.*, the Mercer, which was undoubtedly the first seedling variety, produced in the United States to achieve widespread prominence. Also because of its wide distribution and high degree of excellence it is believed to have played an important part in the production of new varieties from seed in the early part of the 19th century.

The original Mercer potato was produced by John Gilky of Mercer County, Pennsylvania. According to a statement by his

brother James, reported by Hagar and Johnson,[1] who have brought together much information relating to this variety, it was first grown in 1801 or 1802 from seed balls collected the preceding season. The variety was first named Neshanic after a nearby creek and later called Mercer, the name of the county in which it originated. The latter name was retained throughout its period of production in New Jersey and Pennsylvania. In New York, however, it became well known as the Chenango, while in Ohio, Indiana and Illinois it was extensively grown under the name of Neshannock. Other names which are considered synonymous with those given above are Blue Noses, Mashannocks, Nephannocks, Nishenock, Philadelphia, White Chenango and White Meshannock.

Because of its fine appearance, high yield and superior cooking quality it was one of the most popular varieties in this country as late as 1850. It gradually succumbed to the ravages of late blight epidemics which were particularly severe for several years during the decade preceding that date.

Seedlings of this variety were grown in an attempt to develop more vigorous varieties. One of these was named Blue Mercer, which is supposed to be the variety now bearing that name to which reference was made at the beginning of this discussion. So far as is known, the Blue Mercer never attained a prominent place in the commercial trade.

It is felt that serious consideration should be given the lack of uniformity which prevails in designating some of our leading potato varieties.

In the previous reports of this Committee it has been emphasized that old, well-known varieties are frequently advertised and sold under new names by seedsmen. Although much of this stock is purchased for planting in gardens, some is secured by commercial growers who are looking for new varieties. In some instances these lots are increased and eventually entered for certification. If the synonymity of such stock can be detected and certification under the new name refused by the certifying agency, much will be accomplished toward checking the increasing multiplicity of names.

A more prevalent source of confusion, which applies to large quantities of our commercial seed stocks, lies in the use of two or more established names, some of only local application, for a variety in different sections of the country. This situation is revealed by a survey of the seed certification lists from the states which produce certified seed;

[1]Hagar, W. S. and Johnson, George F. 1935. History of the Mercer Potato. (Mimeographed paper.)

e.g., the Russet Burbank is certified under its correct name in two states, as Russets in one state, and as Netted Gem in five states. Much of the crop grown from this Netted Gem seed becomes Russet Burbank when it appears on the Eastern markets. The term Russets, or Russet, is used to designate Russet Rural in one section of the country and Russet Burbank in another. Charles Downing is grown as Idaho Rural in one state and as Earliest of All in an adjoining state.

Mention should be made of the general practice of misnaming the Up-to-Date variety. In the three states in which certified seed of this variety is produced, the certification is under the name of British Queen. This is an entirely different variety, which is not believed to be grown in the United States, though it has not been possible to check material from all possible sources. The lots of so-called British Queen grown in this country which have been studied by the chairman of this committee have proved to be Up-to-Date. In the interest of accuracy, it is urged that this variety be designated only by its correct name.

It is realized that difficulties will arise in attempting to eliminate several of the old names that have been in use for many years, particularly the objections of growers who have established a market for their stock under a certain variety name, or those concerned with the marketing of the crop under names that have long been familiar to the commercial trade.

Where more than one name for a variety is in general use, the question will arise as to which one should be retained. While it would be desirable to follow the established custom which prevails in botanical nomenclature of giving priority to the original name, it is unlikely that this can always be done in the case of potato varieties since in some instances they are grown and distributed, at the present time, under names which have originated since their introduction.

There is not in this country any board or organization which can compel the general use of a certain name for a particular variety. However, much can be accomplished toward the simplification of varietal names by those who are concerned with the seed certification program in the several states if an agreement can be reached regarding the adoption throughout the entire country of a single name for each variety, followed by the refusal of the certification officials to certify fields in their jurisdiction under any other name.

Respectfully submitted,

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RELATIVE EFFICIENCY OF THE TWO-DIMENSIONAL QUASI-FACTORIAL DESIGN AS COMPARED WITH A RANDOMIZED-BLOCK ARRANGEMENT WHEN CONCERNED WITH YIELDS OF IRISH POTATOES[1]

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Much attention has been given in recent years to the question of improved methods of conducting yield tests with a view to reducing the experimental error. Many contributions have been published on this subject and rapid progress has been made in the study and application of better experimental technic to field plot work.

Recently Yates (3, 4) has devised several new designs for yield trials. These designs have been termed quasi-factorial experiments. The two-dimensional quasi-factorial design with two groups of sets may be regarded as the most elementary and probably will be found most useful in varietal testing work.

The relative efficiency of the quasi-factorial design as compared with the ordinary randomized-blocks when applied to yields of Irish potatoes has been studied by Goulden (2). In one test, he obtained a gain of 183.1 per cent in efficiency when using 25 hypothetical varieties and 6 replications.

In the quasi-factorial designs the varieties are divided into groups, in two or more ways, the contents of which form the blocks as shown in figure 1. Because of this smaller block, soil variability is more adequately controlled, which, in turn, usually decreases the experimental error. Of course, where the differences between the blocks are small some loss in efficiency would result as compared with arrangements in ordinary randomized blocks.

Recently, Yates (5) has presented a method for recovering this loss of inter-block information for a three-dimensional quasi-factorial design so that the data can be analyzed as an ordinary randomized block experiment. He proposes to deal with the other types of design in subsequent papers.

Therefore, until such information is made available and tests of significance are included, it is advisable to know something about the

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[1]Cooperative investigations by the Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture, and the Department of Horticultural Research of the Louisiana Agricultural Experiment Station.

[2]Pathologist, Division of Fruit and Vegetable Crops and Diseases.

[3]Agent, Division of Fruit and Vegetable Crops and Diseases.

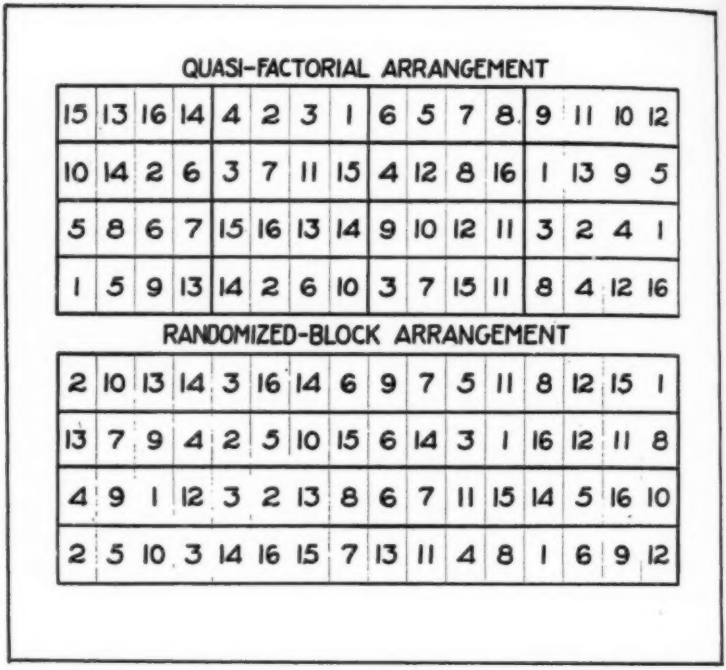

FIGURE 1—Diagrams of a Two-dimensional quasi-factorial and a randomized-block arrangement of plots of 16 hypothetical varieties in 4 replications. (Photograph obtained through courtesy of the Division of Sugar Plants, U. S. Department of Agriculture).

relative efficiency of two-dimensional quasi-factorial designs containing different numbers of varieties. Accordingly, the present study was conducted to determine the relative efficiency of the two-dimensional quasi-factorial as compared with the randomized block arrangement when concerned with the yields of different numbers of hypothetical varieties of Irish potatoes.

MATERIALS AND METHODS

Three sets of uniformity yield data with Irish potatoes were used in this study; one set from Minnesota, one from Canada, and the third from England (2).

Since the data considered were obtained from uniformity trials (*i. e.*, the plots were planted to the same variety of potatoes and at comparable rates), it is possible, by redistribution of assumed varieties, to analyze the data both as a randomized-block and as a two-dimensional quasi-factorial experiment.

The data were analyzed by the analysis-of-variance method (1).

Experimental Data

The analyses of variance for the three sets of data were made on the assumption of 100, 81, 64, 49, 36, 25, 16, 9 hypothetical varieties (where the size of the experiment permitted) in order to test the relative efficiency of the two-dimensional quasi-factorial as compared with the randomized-block arrangement.

The gain or loss in efficiency for the three sets of data is given in table 1. It appears that in the case of the data from England a gain in efficiency of the quasi-factorial design occurred with 49 or more varieties. A gain in efficiency occurred with 36 varieties in the case of the data from Canada. The data from Minnesota gave a slight gain (+6.3 per cent) with 25 varieties and a marked gain with 36 varieties.

Since the yield data used for this study were obtained from such

Table 1—*Relative efficiency of a two-dimensional quasi-factorial design as compared with a randomized-block design in experiments containing different numbers of hypothetical varieties of Irish potatoes at three different locations.*

Number of Varieties	Gain or Loss in Efficiency from Using the Two-dimensional Quasi-factorial Design		
	England	Canada	Minnesota
	Per cent	*Per cent*	*Per cent*
100	+44.9	—	—
81	+31.2	+191.1	—
64	+41.0	+232.5	—
49	+52.0	+213.7	—
36	− 6.3	+115.9	+38.6
25	− 7.4	− 10.2	+ 6.3
16	−10.1	− 10.4	− 8.7
9	−11.7	− 12.8	− 8.5

The writers wish to thank Dr. F. A. Krantz, Dr. L. E. Kirk, Mr. W. G. Cochran, and Dr. F. Yates for making the uniformity data available for the present study.

widely different places, it would seem safe to conclude that, in general, the two-dimensional quasi-factorial design would be preferable when testing 36 or more varieties or strains of Irish potatoes.

It is apparent that the gains in efficiency were much greater in the case of Canada data than with the English or the Minnesota data. This is probably due to a more heterogeneous soil condition where the Canadian test was conducted.

Until some one works out a method for the recovery of the inter-block information for the two-dimensional quasi-factorial experiment, the data in this paper will help the experimenter in deciding upon the type of experimental design to use for variety-yield trials with Irish potatoes.

Summary

The two-dimensional quasi-factorial design of plot arrangement was generally more efficient than a randomized-block design when the tests contained 36 or more hypothetical varieties or strains of Irish potatoes.

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INFLUENCE OF PLANTING DATE ON POTATO LEAFHOPPER POPULATION AND HOPPERBURN DEVELOPMENT[1]

T. C. ALLEN, G. H. RIEMAN AND J. S. MCFARLANE

University of Wisconsin, Madison, Wis.

In their studies of the resistance of numerous potato varieties to hopperburn, Allen and Rieman[1] have indicated that the early-maturing varieties are more susceptible than the late-maturing varieties. Early varieties such as Triumph, Warba, and Earlaine developed a high percentage of hopperburned foliage as compared with such late varieties as Houma, Katahdin, and the Rurals. These preliminary studies suggest that resistance may in some way be associated with late maturity.

The purposes of the present study have been to determine the effect of planting date on the percentage of hopperburn development and upon the leafhopper population. Two resistant varieties, Houma and Katahdin, and two susceptible varieties, Triumph and Warba, were used in the test. Ten hill plantings of each of the four varieties were made at four weekly intervals beginning the 19th of May and ending the 9th of June. The ten hill plantings were replicated twice and the varieties randomized within the plantings.

Weekly records were kept of both percentage hopperburn development and of the nymphal leafhopper population. Foliage collections and nymphal counts were made immediately following the first appearance of hopperburn symptoms and were repeated at weekly intervals for a period of four weeks. Similar data were gathered from the varieties which were grown at each of the different planting dates. In this way

[1]Approved by the Director of the Wisconsin Agricultural Experiment Station. Aid was received from the National Science Division of W. P. A. in the accumulation of data secured from the field plots.

a measure of the hopperburn population and the percentage hopperburn development was secured over a comparable period for each varietal planting.

The method used in determining the percentage hopperburn development was a modification of that described by Allen and Rieman. The sixth leaf from the stem tip was removed from ten plants selected at random from both replicates of a varietal planting and the hopperburned foliage separated from the green foliage by use of a scissors. The percentage hopperburned foliage was then calculated on a dry weight basis. Similar determinations were made on foliage samples collected from all of the different plantings grown at weekly intervals. The results of the forty determinations were averaged.

The nymphal leafhopper population was determined by counting the nymphs occurring on the sixth leaf from the stem tip. Counts were made from ten plants selected at random in both replicates of a varietal

TABLE 1.—*Relation of planting date to potato leafhopper population and percentage hopperburn development in* 1938 *and* 1939 *Kenosha, Wis.*

Variety	Planting Date	Leafhopper Population[1]		Percentage Hopperburn[2]	
		1938	1939	1938	1939
Triumph	May 19	558	417	92.4	72.6
Triumph	May 26	451	308	62.8	52.4
Triumph	June 2	347	248	47.9	30.6
Triumph	June 9	172	166	74.6	15.2
Warba	May 19	277	244	57.4	63.4
Warba	May 26	344	102	59.9	36.3
Warba	June 2	156	182	27.3	17.2
Warba	June 9	78	68	51.9	7.8
Houma	May 19	145	187	17.3	8.3
Houma	May 26	99	109	4.2	8.5
Houma	June 2	115	36	8.3	2.1
Houma	June 9	27	22	1.9	2.9
Katahdin	May 19	137	115	10.1	5.0
Katahdin	May 26	108	61	4.7	2.2
Katahdin	June 2	72	42	2.1	2.7
Katahdin	June 9	47	18	1.8	1.3

[1]Total nymphal leafhoppers counted 4 times at weekly intervals from 10 leaves in each planting.

[2]Average percentage hopperburn from 10 samples of foliage from each planting.

planting. Similar counts were made at each of the four weekly intervals. The counts for the ten leaves were totalled and the average ten leaf counts for the four weekly intervals determined as above.

Percentage hopperburn determinations show that earlier plantings were more severely injured by the leafhoppers as shown in figure 1 and table 1. The injury was most severe on the two early varieties, Triumph and Warba; this relationship holding throughout the season on all plantings. It is to be noted, however, that the percentage hopperburn development was appreciably less on Houma and Katahdin even when they were exposed three weeks longer to leafhopper attack.

The sharp increase in hopperburn development in the plantings made on the 9th of June of Triumph and Warba for the 1938 season, table 1, may be explained by weather conditions. Moisture was lacking at the time and for a period following the final planting and as a result the early varieties were stunted and ripened prematurely. Such host and weather conditions favored a rapid hopperburn development. The late varieties were similarly stunted during their early growing period, but were able to resume growth following late season rains.

The nymphal leafhopper population was likewise greater on the earlier plantings, as shown in figure 2 and table 1. The early varieties,

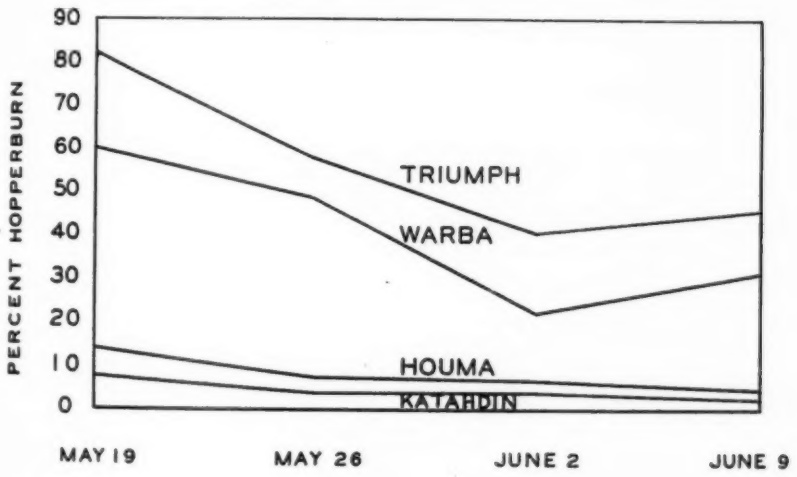

FIGURE 1—Average per cent hopperburn development on potato varieties planted at four successive weekly intervals during 1938-1939, Kenosha, Wisconsin. Average per cent hopperburn determined from ten leaves collected at four weekly intervals. (Results represent a two-year average).

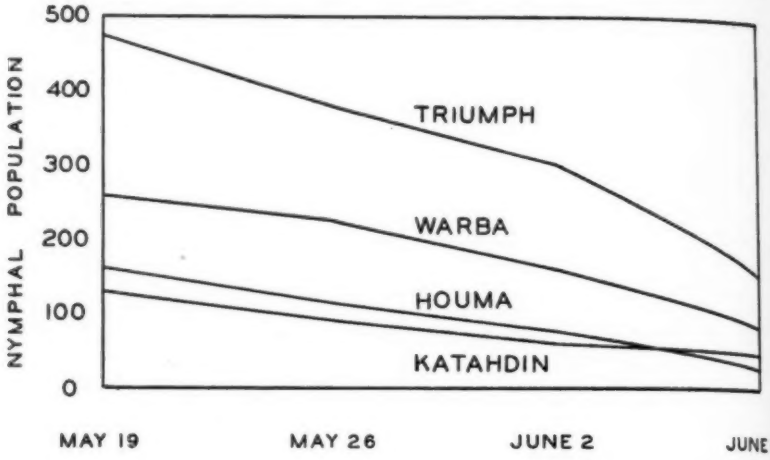

FIGURE 2—Average number of potato leafhopper nymphs occurring on potato varieties planted at four successive weekly intervals during 1938-1939, Kenosha, Wisconsin. Total nymphs from ten leaves counted at four weekly intervals and the four counts averaged. (Results represent a two-year average).

Triumph and Warba, proved more attractive throughout the season than did the late varieties Houma and Katahdin. The number of nymphs appearing on Houma and Katahdin when planted on the 9th of June, however, was no greater than that occurring on Triumph when exposed to leafhoppers three to four weeks longer. These observations indicate that there are factors other than earliness or lateness which influence the resistance of potato varieties to hopperburn.

CONCLUSIONS

Percentage hopperburn development was greater in the early maturing varieties than in the late maturing varieties regardless of the planting date.

Percentage hopperburn development was reduced by deferring the planting date with both early and late varieties of potatoes.

Nymphal leafhopper population is closely correlated with percentage hopperburn development in respect to time of planting.

The results indicate that the relative earliness or lateness of a variety is not the prime factor in determining its resistance or susceptibility to hopperburn.

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DESICCATION EFFECTS ON SKINNED POTATOES

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Skinned or "feathered" places on potatoes frequently turn brown or even black. This discoloration is commonly referred to as "sunburn" or "sunscald," although the latter term is usually applied to the soft puffy condition which characterizes areas that have become infected with bacterial soft rot, after being initially injured by exposure to hot sunshine or otherwise. The discoloration referred to herein is often most severe on the bud end. There is no doubt that such browning or blackening occurs when potatoes are left lying in the hot sun after being dug. Such exposure also increases their susceptibility to infection by bacterial soft rot. However, recent investigations at the U. S. Department of Agriculture have shown that the discoloration can be caused, and possibly is caused chiefly, by exposing skinned potatoes to conditions that dry them rapidly, with or without heat, soon after the skinning occurs. This is true with new or immature potatoes as well as with those that are fully mature, the important difference between the two, from a commercial standpoint, being that the former are more easily skinned and thus more subject to the discoloration.

Potatoes of the Cobbler, Chippewa, Russet Rural, Russet Burbank, Katahdin, and Green Mountain varieties were skinned or feathered and then exposed for various lengths of time to blasts of dry air in the laboratory. The air moved at the rate of approximately 250 to 300 feet per minute and had a relative humidity of 25 to 30 per cent and a temperature of 70° F. A comparable test was conducted in very moist air moving at the same velocity. The relative humidity was 95 to 98 per cent, and the temperature was 80° F. Skinned potatoes of these same varieties were also exposed in still air to the humidities and temperatures just mentioned. The air velocities used are roughly equivalent to a breeze of only 2¾ and 3½ miles per hour, and the 25 to 30 per cent humidity is about the same as that which often prevails in potato fields at digging time, especially during the middle of the day.

After the various tests were ended, the potatoes were held for observation either at room temperature or at 60° F. for several days to several weeks. It was found that skinned tubers of all six varieties

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showed pronounced browning and shrinking or sinking of the skinned surface after being blown for half an hour or longer in dry air. With increasing age these areas became very dark brown or black, and the adjacent tissue became badly wilted from loss of water. As is frequently observed on the market it was often most pronounced at the bud end. The most severely browned was Katahdin and the least was Russet Rural. Those blown in very moist air for as long as 24 hours showed no browning or shrinking, except the slight discoloration that had occurred on the Russet Burbank as soon as it was skinned, regardless of whether the air was dry or moist.

Potatoes in still dry air browned less than those that were blown in dry air, and potatoes in still moist air failed to brown just as did those that were blown in moist air. From these results it appeared that exposure to moist air prevented the discoloration, and exposure to dry air produced it. These conclusions are also supported by unpublished results obtained by W. R. Barger of this Division in some work conducted on the White Rose variety in 1938 at Shafter, California.

To determine how long it is necessary to hold skinned potatoes in moist air to protect them against discoloration, tubers of all six varieties were blown in very moist warm air (relative humidity 95 to 98 per cent, temperature 80° F.) for 3, 5, 7, 9, 12, 15, 18, 21, and 24 hours. No discoloration occurred while they were being blown. After they were removed from the air blast and high humidity they were held in dry still air at room temperature for 24 to 48 hours. All those blown for 9 hours or less showed marked browning and considerable shriveling after 24 hours; all those blown 12 hours or more remained free from browning and did not shrivel. The probable explanation for the difference is that exposure to moist air for more than 9 hours allowed suberization of the skinned surface to take place, and this protected those areas from browning and loss of moisture. Artschwager (1) has reported that at 70° to 95° F. and high humidity suberization of the cut surface of Irish Cobbler and Russet Rural potatoes appeared after 1 day.

Skinned potatoes of the six varieties mentioned were also exposed to air blasts of about 500 feet per minute, in cold storage rooms held at temperatures of 42° and 50°. Despite the fact that the relative humidity in these rooms ranged from 80 to 85 per cent, browning began to appear after the tubers had been blown for an hour or more. This was probably because, as Artschwager has shown (*loc. cit.*), within this range of temperature, suberization does not occur until after 3 days. The temperatures in this test were far below any that have been thought of as capable of causing "scald," yet the type of injury encountered

was in all respects identical with that produced at higher temperatures. Limited tests conducted with the Bliss Triumph variety indicated that it was much less susceptible to browning than any of the other varieties, except possibly Russet Rural. The browning in all the varieties undoubtedly resulted from oxidation of some substance, probably tyrosin in the tuber, but the precise relation between it and the various contributing factors is still under investigation. In these experiments some of the discolored skinned areas became sticky, but none of them developed typical bacterial soft rot.

Conditions similar to those established in the experiments discussed above may exist in the field on any clear dry day. If in addition to low humidity there is some wind and intense sunlight the browning may become accentuated, as has been observed at times in the Southern early potato-growing sections and in California. In the late-crop-producing sections of the West and Northwest, where the weather may be quite cool at digging time, the browning is not necessarily associated with high air temperatures in the field. It was quite common, for example, on skinned Russet Burbank and Katahdin potatoes in southern Idaho early in October, 1939. The maximum air temperature during the first 5 days of the month ranged from 58° to 60° F. and the minimum from 36° to 44°. These are decidedly not the kind of temperatures that are commonly thought to cause "sunscald" in potatoes. In view of the facts brought out herein the terms "sunscald" and "sunburn" are erroneously applied to this injury, which can be more properly defined as a desiccation accompanied by more or less severe discoloration of affected areas.

The discoloration is probably of greatest importance in the early potato sections, particularly in the Southern States and in California. In shipments from these sections the discolored areas on the tubers may so detract from their appearance that their market value is severely discounted. This is true even when bacterial soft rot does not become a factor, as it may frequently in sections where the potatoes are dug in hot or muggy weather.

Early in May of this year (1940) the Federal Food Products Inspection Service noted severe discoloration on skinned areas on new potatoes shipped to northern markets from the South. The browning was usually most pronounced on the tubers most exposed to the sweep of the air through the cars, which moved under ventilation. These observations support the results of the experiments here reported, that the discoloration is caused by rapid drying of the skinned areas, and not by heat.

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A SECOND REPORT ON THE EFFECT OF AGRONOMIC PRACTICES ON THE INCIDENCE OF RHIZOCTONIA AND SCAB OF POTATOES

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In a previous report (Blodgett 1939) an account was presented of the effects of length of rotations, applications of commercial fertilizer and of manure and the use of a rye cover crop on the incidence of the sclerotia of Rhizoctonia on potato tubers. The nature of the rotations will be evident from an examination of table 1.

Table 1.—*Percentage of tubers with sclerotia of Rhizoctonia.*

Rotation Numbers	Byron		Malone		Cohocton		Average		Average
	1938	1939	1938	1939	1938	1939	1938	1939	Two Years
10	14.4	60.8	53.5	59.2*					
1	8.0	34.2	39.0	59.4	46.4	60.1	31.1	51.2	41.2
4	8.0	7.9	26.2	50.6	38.7	62.0	24.3	40.2	32.2
2	5.3	15.9	31.1	42.8	37.5	51.1	24.6	36.6	30.6
3	6.0	4.7	14.0	21.6	26.5	53.1	15.5	26.5	21.0
5	2.7	4.7	7.0	15.1	6.3	20.9	5.3	13.6	9.4
6	2.4	8.7	7.2	16.5	10.5	30.6	6.7	18.6	12.6
7	2.0	5.7	3.7	3.9	4.1	22.5	3.3	10.7	7.0
8	4.0	1.3	5.8	9.2	.7	17.0	3.5	9.2	6.3
9	3.5	4.0	13.2	8.5	1.6	20.1	6.1	10.9	8.5
							13.4	24.2	18.8

*Manure added in 1939.

Although the results reported for 1938 were statistically highly significant and fairly consistent in the three locations, it is desirable to know whether similar results will be obtained in succeeding years with the changes in weather and other conditions. For this reason a second report may be permissible, although only a long period of tests will determine how regularly such results may be expected.

If the data on the percentage of tubers having sclerotia of Rhizoctonia, as presented in table 1, for the two years at three places are examined together, it will be noticed that there have been consistently more tubers affected at Cohocton followed in order by Malone and Byron. There was a considerable increase in Rhizoctonia in 1939 compared with 1938 and the increase was greater at Byron and Cohocton than at Malone. No reason may be assigned with certainty for this general increase in Rhizoctonia though it is known that the seed, even

PRINCIPAL CHARACTERS OF ROTATIONS

Fertility added in 1-year rotations.

Rotation Numbers	Length in Years	Commercial Fertilizer	Manure	Cover Crop
10	1	0	0	0
1	1	+	0	0
4	1	+	0	+
2	1	+	+	0
3	1	+	+	+
5	2	Field beans (or soy beans)—potatoes		
6	2	Corn potatoes		
7	2	Clover & timothy or sweet clover—potatoes		
8	5	Beans-wheat-clover & timothy (or alfalfa) 2 years—potatoes		
9	5	Wheat-clover and timothy (or alfalfa) 2 years—beans—potatoes		

Cover crops were used in 2- and 5-year rotations when the land was not otherwise occupied.

though untreated, was relatively clean at all three places in 1939. It cannot be explained on the basis of accumulation in the short rotations as the increase was relatively larger in the long rotations than in the short rotations.

In spite of these changes in amounts from year to year and at the different places, the different rotations have maintained essentially the same order as regards the number of tubers bearing sclerotia of Rhizoctonia. The one-year rotations (potatoes every year) (numbers 1-4) are ahead with 38.6 per cent of tubers with Rhizoctonia in 1939, the 2-year rotations (numbers 5-7) next with 14.3 per cent; and the 5-year rotations (numbers 8-9) last with 10.0 per cent.

Similarly among the one-year rotations, the effects of fertilizer, manure and cover crops have continued. At Byron, the only place where number 10 rotation was continued, growing potatoes every year without either fertilizer, manure or cover crop, the tubers from this rotation gave 60.8 per cent with *Rhizoctonia* as contrasted with 34.2 per cent on rotation number 1 with only fertilizer added and 4.7 per cent on rotation 3 which had fertilizer manure and rye cover crop. At Malone, where previously rotation number 10 was the same as at Byron, a change was made this year and manure was added. While last year this rotation number 10 at Malone gave the highest percentage of tubers with Rhizoctonia at that place; this year, with manure used, it gave a crop with approximately the same amount of *Rhizoctonia* as rotation number 1, where commercial fertilizer was used, thus showing a prompt response to the use of manure.

The remaining one-year rotations (Nos. 1-4) have had uniform treatments at all three places. Of the one-year rotations number one, in which only fertilizer is applied showed the largest percentage (41.2 per cent) of tubers with Rhizoctonia. The plots with a rye cover crop (rotation 4) showed 32.2 per cent; thus there was a difference of 9 in the percentages of tubers affected. The plots receiving manure showed 30.6 per cent of tubers with sclerotia, a difference of 10.2 per cent in favor of manure. The use of a cover crop and manure gave only 21 per cent of affected tubers, a difference of 20.2 from rotation one where neither was used. In other words, both manure and the rye cover crop reduced the percentage of tubers with *Rhizoctonia* when used alone and, when used together, the effects are additive.

When the results of the four one-year rotations (nos. 1-4 were examined as a small factorial experiment by the analysis of variance methods, the following conclusions can be drawn from the analysis:

The manure and the rye cover crop each had the same effect in controlling *Rhizoctonia* when used together, as when used separately.

Manure had essentially the same average effect in each of the different places and the same average effect in 1938 as in 1939. At each of the three places, the results in 1938 were consistent with those in 1939.

With the rye cover crop, there was a variation in results. Although, on the average, there was a highly significant reduction in *Rhizoctonia*, this was not obtained in each year at each place. Thus there was no

TABLE 2.—*Interaction of rye cover crop by years and places.*

Percentages with Rhizoctonia.

Year	With	Without	Difference	Dry Weight Rye Lbs. per Acre
	Byron			
1938	7.0	6.7	− .3	1530
1939	6.3	25.1	18.8	2670
	Malone			
1938	20.1	35.1	15.0	844.5
1939	36.1	51.1	15.0	155.5
	Cohocton			
1938	32.6	42.0	9.4	216.5
1939	57.6	55.6	−2.0	139.5(3)*
			9.3	

*Figure given for Cohocton 1939 is for Rotation 3. Rotation 4 was much poorer and not sampled.

reduction in Byron in 1938 but a good reduction at the same place in 1939 as shown in table 2. There was a significant reduction in *Rhizoctonia* at Cohocton in 1938 but none at the same place in 1939. At Malone, a marked reduction was obtained in both years. The data for the dry weight of rye plowed under have been included in table 2 for comparison with the *Rhizoctonia* control results. The cover crop was poor for Byron in 1938 and very poor for Cohocton in 1939, but there are, by comparison, enormous differences between the amount of cover crop in the different places, and at Malone between the amounts in the two years. The relation between the amount of cover crop and *Rhizoctonia* control is, therefore, apparently not very close.

As regards the control of common scab, little can be said as yet. The situation varies at the different places. At only one place, Byron, is the pH of soil (ranging from 5.5 to 7.0) such as to be naturally favorable to scab. Here there was almost no scab in the first year of the experiment (1936) and the increase has been surprisingly slow. There is more on the average in the rotations where potatoes are continuous than in longer rotations. Among the one-year rotations, the only clear-cut difference is that rotation number 10, which receives no fertilizer, manure or cover crop, has significantly more scab than the others. This parallels the results with *Rhizoctonia*.

At the other two places, no consistent relation of scab to the rotations is apparent. At one of these places, Malone, lime was applied in small amounts early in the course of the experiment, in an effort

TABLE 3.—*Percentages of scabby potatoes—rotation experiments*

Rotation Numbers	1938	1939	Average	Length of Rotation	Fertilizer	Manure	Rye Cover Crop
1	11.2	12.1	11.6	1 year	+	0	0
2	13.3	12.8	13.1		+	+	0
3	9.6	11.2	10.4		+	+	+
4	8.4	6.9	7.7		+	0	+
5	2.0	7.7	4.9	2 years	Beans		
6	2.6	10.6	6.6		Corn		
7	1.9	4.5	3.2		Sweet Clover		
8	2.6	3.6	3.1	5 years	Beans and alfalfa		
9	3.5	1.9	2.7				
10	15.4	22.3	18.9	1 year	0	0	0
Sign. Dif.	7.05 7.07	9.4 7.07	8.2 5.0				

to even up the soil acidity. Two of the plots that were limed happened to be plots of rotations in which manure was also being used and these have regularly given the highest scab counts. At both Malone and Cohocton the practice of using lime (1500 pounds per acre) when seeding for clover in both two and five-year rotations was begun after the experiment was underway for a year. Some of these plots were planted to potatoes in 1938 and 1939. The data at these two places are accordingly classified as to whether manure or lime or both have been applied. At Malone, the 2 plots receiving both lime and manure were so high in scab that, although only two plots are involved, the difference appears to be highly significant. Both lime and manure used separately have also caused increase in scab at Malone which are large enough to be statistically significant and to cause a small loss. At Cohocton only traces of scab have appeared so far, and this was in the 1939 crop as revealed in table 4, from the plots which have been limed.

TABLE 4.—*Percentages of scabby potatoes*

	Malone 1938		1939		Cohocton	
	No. Plots	Percentage Scabby	No. Plots	Percentage Scabby	No. Plots	Percentage Scabby
Lime and Manure	2	62.7	2	84.8		
Lime	13	4.4	19	11.4	15	5.47
Manure	8	4.3	8	12.3	10	.4
No lime or Manure	27	.3	21	2.4	20	.4

SUMMARY

The results obtained in three rotation experiments in New York State in 1939, confirm the report made in 1938. They are as follows:

More potato tubers bore sclerotia of *Rhizoctonia* where potatoes were grown continuously than where they were grown in longer rotations.

Where potatoes were grown continuously, the largest percentage of tubers were affected with *Rhizoctonia* where they were grown without commercial fertilizer, manure or cover crop. The addition of fertilizing material in any of these forms reduced the percentage of tubers

affected, and the greatest reduction was secured on plots where all of these fertilizing materials were used together.

At the only location where the pH of the soil was such as to favor scab, the largest amount occurred on plots which received no fertilizer, manure or cover crop. At the other locations small increases in scab occurred on plots which had been previously limed for clover. The largest increases were obtained on plots which received both manure and lime. Manure alone has caused a small increase at Malone.

LITERATURE CITED

Blodgett, F. M. 1939. The effects of some agronomic practices on the incidence of Rhizoctonia. Amer. Potato Jour. 16: 93-98.

REPORT OF SEED CERTIFICATION COMMITTEE—1939

This part of the report pertains only to very general conditions covering the country as a whole. More specific information will be secured by referring to the sectional notes published in the American Potato Journal during the course of the season.

The Fourth Annual Conference of the High Plains Potato Workers was held at Scottsbluff, Nebraska, 19th and 20th of August, 1939. This was attended by more workers, including a greater number of states, than any previous conference. Representatives from the U. S. D. A., Utah, Montana, Alabama, North Dakota, in addition to the regular states of Wyoming, Colorado and Nebraska, were in attendance. All features of potato production were discussed, most lively of which revolved around tolerances to be allowed for bacterial ring rot. A meeting of certification officials in the eastern states was again held. These meetings are of very great value, and their continuance should be encouraged.

A preliminary report of the results of experimental work conducted by the U. S. D. A. Division of Fruit and Vegetable Crops and Diseases, showing the effect of different percentages of Spindle Tuber on yield of potatoes, has been made. They are making plans to continue this work.

The State of Oklahoma continues with special regulations and inspections on non-certified potatoes. This set-up is intended to improve and control importation of potatoes intended for seed purposes by cutting down on visible diseases such as scab, rhizoctonia, and stem end discoloration. The only change noted since last year is that the method in which the check is made for stem end discoloration now conforms

with the Federal-State inspection services in operation in various northern states. This is of primary interest to growers and shippers of commercial or non-certified potatoes.

The State of Arkansas has proposed broadening of their own state regulations and in general, will conform with special regulations already in force in Oklahoma. These regulations also apply to visible diseases to be found on non-certified seed potatoes. In addition to the diseases mentioned in this regard, a tolerance of 1.0 per cent for ring rot is proposed. This is not proposed, nor recommended by the Committee, but simply reported upon as indicating trends in some states.

In the western states, where psyllid yellow infestation was so severe during 1938 the general report is that a very small amount of trouble occurred during 1939. One result of the severe infestation in 1938 was the establishment by the U. S. D. A. Bureau of Entomology, of an office, to study the trouble. This office is located at Scottsbluff, Nebraska, and is intended to serve adjoining states in the inter-mountain area.

Grasshopper difficulties which have been on the increase for a number of years, particularly in western and northern states, apparently have subsided in a number of sections. Part of this is apparently caused by the natural cycle of decline, and in other sections, to a broad and comprehensive control program. Several of the western states, in addition to the regular grasshopper control in cultivated fields, have a range and grassland control program.

Recommendations of the Committee

1. Promotion of further research work in U. S. D. A. on bacterial ring rot.

2. Continuation of experimental work, initiated by the U. S. D. A., relative to the effect of virus diseases on yields.

3. Adoption of the so-called "zero tolerance" by Seed Certification agencies.

4. In view of the new varieties being introduced, to allow a broader tolerance for variety mixtures by permitting roguing and reinspection.

5. Development of ways and means to further control the so-called "Selected Seed."

6. Seed certification agencies should give special consideration to the production and distribution of foundation seed. Special disease tolerances should be set up, distinctive tags used, and other features to distinguish this class of seed from general Certified.

7. In the event of the rise of special disease problems which appear to be confined to localities, a declaration of quarantine on certification be made until the nature of the disease and its control are known.

8. Seed certification agencies should conduct cooperative experiments to develop a uniform and reliable method of testing seed potato stocks to determine their disease content.

9. In all states, the seed certification program should be developed hand in hand with all other potato programs within the State, such as Plant Pathology, Horticulture, or Agronomy, Plant Breeding, etc.

10. All State Certification Agencies should work in close cooperation with the U. S. Department of Agriculture, and other potato breeding projects on the introduction of new varieties.

11. Urge all importing states to consider ways and means of furthering the sale and distribution of Certified seed, in addition to, or in lieu of, enacting regulations controlling the sale of non-certified seed shipped into the State. (Also recommended in 1938).

12. Announcements of various meetings, and sectional conferences of general interest to potato workers should be made well in advance of their time of meeting, in the American Potato Journal.

Persons Directing Seed Potato Certification in Various States

(Where Production is on a Commercial Scale)

H. W. Poulson, Dept. of Agriculture, Sacramento, California

C. H. Metzger, Agricultural Experiment Station, Fort Collins, Colorado

E. R. Bennett, College of Agriculture, Boise, Idaho

J. F. Percy, Pure Seed Specialist, L. S. U., University, Louisiana

E. L. Newdick, Dept. of Agriculture, Augusta, Maine

R. A. Jehle, Agricultural Experiment Station, College Park, Maryland

H. C. Moore, State College, East Lansing, Michigan

A. G. Tolaas, Dept. of Agriculture, St. Paul, Minnesota

E. E. Isaac, State College, Bozeman, Montana

Marx F. Koehnke, Certified Potato Growers, Alliance, Nebraska

K. H. Fernow, Cornell University, Ithaca, New York

R. C. Hastings, State Seed Commissioner, Fargo, North Dakota

E. R. Jackman, Oregon Agricultural College, Corvallis, Oregon

K. W. Lauer, Dept. of Agriculture, Harrisburg, Pennsylvania

John Noonan, South Dakota Potato Growers Association, Watertown, South Dakota

Victor P. Rasmussen, Asst. Sec'y-Treas., Utah Crop Improvement Assn., 306 State Capitol Bldg., Salt Lake City, Utah

H. L. Bailey, Dept. of Agriculture, Montpelier, Vermont
Chas. D. Gaines, Dept. of Agriculture, Olympia, Washington
J. G. Milward, College of Agriculture, Madison, Wisconsin
G. H. Starr, University of Wyoming, Laramie, Wyoming
John Tucker, Dept. of Agriculture Ottawa, Canada.

STATES PRODUCING LESS THAN 10,000 BUSHELS

Service discontinued in Arizona
M. S. Yeomans, State Entomologist, Atlanta, Georgia
R. W. Samson, Purdue University, Lafayette, Indiana
J. S. Gardner, Agricultural Experiment Station, Lexington, Kentucky (very small acreage)
O. Butler, Durham, New Hampshire
Paul B. Mott, Dept. of Agriculture, Trenton, New Jersey
Clayborne Wayne, Ext. Agronomist, State College, New Mexico
G. K. Middleton, N. C., Crop Improvement Association, Inc., Raleigh, North Carolina
E. B. Tussing, State University, Columbus, Ohio (Service Inactive)
G. M. Bentley, Dept. of Agriculture, Knoxville, Tennessee (Increasing)
R. V. Miller, Chief Division Field Seed Certification, Dept. of Agriculture, Austin, Texas (Service Inactive)
S. F. Grubbs, Va. Crop Improvement Assn., Blacksburg, Va. (Inactive)
F. Waldo Craig, Dept. of Agriculture, Charlestown, W. Virginia (Service Inactive)

COMMITTEE

R. J. Haskell, Senior Extension Plant Pathologist, U. S. Department of Agriculture, Washington, D. C.
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J. G. Richard, Louisiana State University, University, Louisiana
Marx Koehnke, *Chairman,* Nebraska Certified Potato Growers, Alliance, Nebr.

GENETICS, CYTOGENETICS AND BREEDING IN THE POTATO: REVIEW OF LITERATURE[1]

F. J. STEVENSON[2]

Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, Washington, D. C.

This review of literature shows that genetics, cytogenetics and potato breeding are on the increase and that a number of interesting lines of investigation are being attacked.

Much of the material shows progress in lines of work that have already been brought to the attention of this Association by its Research Committee. A few results are especially noteworthy:

1. The interesting and useful paper on potato genetics by Lunden (22) in which he discusses his own investigations and the results of others and shows that the geneticist is dealing with tetrasomic inheritance in his work with the potato. An abstract is not included in this report, since one was given by Clark (5) in his review of literature for 1937. Recently the paper has been translated, however, under the supervision of F. A. Krantz of the Division of Horticulture, University of Minnesota, Agricultural Experiment Station. Assistance in the preparation of the translation was furnished by the personnel of the Works Progress Administration, Official Project No. 665-71-3-69, Sponsor, University of Minnesota. As soon as possible mimeographed copies of this paper will be made available to cooperators in the National Potato Breeding Program and others interested in potato genetics. I mention this paper here because I believe it is one of the outstanding contributions of recent years to potato genetics and because I agree with what Dr. Krantz wrote in a letter to me enclosed with a copy of the translation. He said, "It seems to me that any one who intends to make a contribution to our knowledge of potato breeding and genetics must take cognizance of this paper and be familiar with its contents. It would facilitate future progress if all the cooperators had a copy of the translation." Tetrasomic inheritance helps to explain some of the absurdities that were apparent in the genetic results when these were viewed in the light of disomic inheritance only.

2. Another contribution to the genetics of pollen sterility.

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[1]Much of the material in this report, especially that concerning articles written in foreign languages, was taken from the abstracts published by the Imperial Bureau of Plant Genetics, Cambridge, England, and The Review of Applied Mycology.

[2]Senior Geneticist, U. S. Department of Agriculture, Bureau of Plant Industry.

Again it's STATE OF MAINE for CERTIFIED SEED POTATOES In 1940-41

FRANK P. WASHBURN
Commissioner

Department of Agriculture
State of Maine
Augusta

E. L. NEWDICK
Chief, Division Plant Industry
STANLEY L. PAINTER
Horticulturist

October 17, 1940

Frank P. Washburn, Commissioner
Maine Department of Agriculture
State House
Augusta, Maine

Dear Mr. Washburn:

At your request I am submitting herewith a statement covering the certification of seed potatoes for the season of 1940.

[illegible] completed our digging inspection and have passed a total of 26,872 acres

All others [illegible] 2,217 Acres

[illegible] the job whose work began with the growing [illegible]
[illegible]tions during the growing season. Every field

seed potatoes for the

completed our digging inspection

All Others Thereon 2,217 Acres

We have employed 21 trained inspectors on the job whose work began with the growing plants on June 24th. All fields have had two inspections during the growing period and much of this acreage was visited several times during the season. Every field has been inspected during digging operations and the place of storage noted.

Seven million bushels of certified State of Maine seed of all varieties will be available for distribution to the States that purchase seed from us and for our growing export trade. Five cars of Katahdins have already been shipped.

The outstanding feature of this year's crop is that, in spite of high yields, tubers are of uniform size. Our growers have apparently planted rows closer together than in previous years. This is especially true of Irish Cobblers. The color is exceptionally bright and this particular variety appears outstanding for yield, color and even size.

This preliminary report is submitted for your immediate information and later we will be glad to give you more detailed information.

Respectfully submitted,

E. L. Newdick

E. L. Newdick, Chief
Division of Plant Industry.

STATE OF MAINE
CERTIFIED
SEED
POTATOES

For a copy of "Potatoes Inspected and Certified in Maine, 1940" and list of Maine Certified Seed Potato Shippers write or wire E. L. Newdick, Chief Division of Plant Industry, Department of Agriculture, Augusta, Maine. Copies of Field Inspection Reports are also available to you on request.

MAINE DEVELOPMENT COMMISSION
PRODUCTS DIVISION **AUGUSTA, MAINE**

3. Additions to our knowledge of resistance to the degeneration diseases; with resistance to viruses A and Y, immunity from X, and tolerance to leaf roll accomplished facts.

4. Further information on immunity from and resistance to the fungus diseases, late blight and common scab, and immunity from potato wart.

5. Resistance to a bacterial disease, the brown rot.

6. Drought resistance.

7. Additional evidence of resistance to the attacks of leafhoppers and Colorado beetles.

8. Resistant mutations from susceptible varieties.

9. Discussions of so-called "graft-hybrids" giving information on relationships and influences of scion and stock which on the surface might appear fantastic but which with the increased knowledge that is being accumulated concerning plant hormones is probably sound. If so, it opens another avenue of attack for the plant breeder and may be the only method by which some of his problems can be solved.

The abstracts which follow are classified according to the subject that seems to be given the greatest emphasis:

Genetics

Krantz *et al* (19) made a study of fruit setting and pollen sterility in a large number of selfed lines of the potato. Both characters, especially fruit setting, were subject to fluctuation due to environment.

The inheritance of pollen sterility (as determined by the amount of stainable pollen) was studied in a cross between Lookout Mountain and an un-named variety, Accession 123. The results could be explained by the hypothesis of a single lethal pollen gene and tetrasomic inheritance, AC 123 denoted as VVvv and Lookout Mountain as Vvvv. It appears that under the conditions of the experiment about 65, 20 and 10 per cent, respectively, of VV, Vv, and vv pollen were viable.

The viability of the pollen in most of the plants of the progeny was sufficient for seed setting. It is suggested that the high pollen sterility of many cultivated potato varieties is the result of selection and is not characteristic of the species as a whole. The presence of other characters such as restricted production of flowers and early abscission of flowers in cultivated potatoes suggests that selection for high yield has been instrumental in selecting genes adversely affecting sexual reproduction.

Becker (2) studied the inheritance of certain characters in the interspecific cross *Solanum demissum* Lindl. *v Solanum tuberosum* L.

Solanum demissum is a small prostrate, late-maturing species with narrow cotyledons, small leaves, long stolons, many small tubers, and 72 chromosomes (2N). The *Solanum tuberosum* selection 4-39-2-2, the pollen parent, is a large, erect, early-maturing, frost-tender selection with wide cotyledons, medium sized leaves, short stolons and many *medium-sized tubers.*. *Solanum tuberosum* has been reported to have 48 chromosomes (2N). The 60-chromosome hybrids between those species showed considerable irregularity in meiosis, non-oriented and lagging chromosomes being usual. Fifteen plants were raised of which 3 were fertile enough to produce seed for F_2 families. One F_2 family was practically identical with *Solanum demissum* in morphological characters and was uniform. The other two F_2 families approached *Solanum tuberosum* in morphological characters and were variable. The chromosome counts in 15 plants of one of these families ranged from 48 to 58. These F_2 families showed a range from the extreme of one of the original parents to the other in cotyledon measurements, stem diameter, heat injury, maturity, frost injury, stolon length, number of tubers and weight of the largest tuber, with the means falling halfway between the parent lines. The height of mature plants and internode length resembled *Solanum demissum* more than 4-39-2-2, whereas the weight of the crop was similar to that of the cultivated parent. Terminal leaflets and mature leaves were larger than those of either parent.

Cytogenetics

Propach (29) reported cytogenetical investigations. The triploid hybrid (2n=36) studied was *Solanum acaule* (2n=48) x *Solanum chacoense* (2n=24). Analysis of 50 cells at metaphase I of meiosis gave an average per cell of $6.40_1 + 8.72_2 + 4.10_3$. The tetraploid hybrid (2n=48), *Solanum demissum var. kotzchii* (2n=72) x *Solanum verucosum* (2n=24) gave from a similar analysis $2.48_1 + 17.64_2 + 0.90_3 + 1.96_4$. The tetraploid hybrid *Solanum demissum f xitlense* (2n=72) x *Solanum chacoense* was also studied and though a sufficient number of well fixed cells for analysis were not obtained, there was evidence that the chromosome conjugation was similar to that in the former tetraploid hybrid. The similarity between the author's data and those obtained by Upcott in autotriploid and autotetraploid tomatoes is pointed out and the conclusion reached that the polyploid Solanum forms studied are auto-polyploids, though it is conceded that minor structural differences between corresponding chromosomes of the different genoms probably occur.

The regular bivalent formation which occurs in the polyploid species, in spite of their autopolyploid nature, is discussed.

Bukasov (4) emphasizes once more the difference between the Andigena group and *Solanum tuberosum,* the former short day forms confined to the tropical belt. An outline is given of the present systematics of the potato including the 18 new cultivated and 65 wild species and their ecological characteristics are indicated.

In order to investigate the value of the new material from the point of view of practical plant breeding, hundreds of thousands of cross pollinations have been made, 500 of which were interspecific. Of these, 200 were successful and produced offspring. All 15 diploid species, even from widely separated systematic ecological or geographical groups, are interfertile. The 10 triploid species rarely give results when intercrossed. The tetraploid species are interfertile when species belonging to closely related groups are crossed; chromosome duplication usually occurs in the production of such hybrids or their progeny. The male sterility of the two known pentaploid species has prevented their being crossed.

Crosses between species differing in chromosome number are usually successful if the chromosome numbers are multiples (2n=24, 48, or 72). The triploid species are very difficult to cross with other species. Of the pentaploid species, one, *Solanum curtilobum,* crosses with diploids and tetraploids; the other, *Solanum semidemissum,* does not. The hexaploid, *Solanum demissum,* will cross reciprocally with *Solanum tuberosum.* Backcrosses between species hybrids and *Solanum tuberosum* give better results when different, rather than the same, varieties of *Solanum tuberosum* are used each time. Other methods used are intercrossing F_1 and F_2 plants; backcrossing F_2 plants followed by further crossing with *Solanum tuberosum* which, according to Puskarev, should be used as the female parent. Hybrids of three or more species are also of interest: first crossing with a third bridging species is sometimes the only practical way of combining two species that do not cross directly, or a third species may be used to introduce the "supplementary" yield factors absent in domestic varieties. Many of the hybrids of the primitive species with domestic varieties have given yields exceeding those of the latter by 140-150 per cent. Many of these are promising from a commercial standpoint and are being increased for distribution.

Resistance to Virus Diseases

Observations by Müller (27) at Dahlem where potatoes are particularly subject to degeneration show that the varieties differ in the

degree to which the yields are reduced from year to year and also in their ultimate yields. Two new varieties, 9233 and 9089, have given better yields in the tenth year of cultivation than those obtained from the best of the ordinary varieties in the fourth. Variety 9089 is a selection from a cross of an Indian variety from Chiloc with Dolkowski's variety Switez the hybrid having been backcrossed with one of Broili's land races. One of the selections from the backcross when selfed gave seedling 9089. All the seedlings had 48 somatic chromosomes. Variety 9089 is more resistant than 9233, except that 9233 was completely resistant to Y virus, but certain plants of 9089 were attacked by it. The seedlings were grown for 6 years in Dahlem and some of the lines have proved distinctly superior to the most resistant cultivated varieties yet known. A high degree of tolerance to the leafroll virus was observed in 9089.

Selfing 9089 and the variety Erdgold showed both to be heterozygous for resistance to leafroll and stipple streak. The selfed progeny was much less attacked with leafroll than that of Erdgold, whereas the hybrids between the two varieties were intermediate. The progenies of reciprocal crosses were identical. The results showed that resistance to degeneration can be combined with mid-early maturity, wart resistance, good yield and tuber form, short stolons and resistance to blight biotype A. Some of the seedlings of the cross Ackersegen x 9089 were more resistant than either parent, especially as regards resistance to the Y virus. A hybrid of Deodara x 9089 has been grown 5 years without a single infection with stipple streak and in other hybrids there are indications of resistance to mosaic. It is considered possible that forms with true resistance to leaf roll as contracted with the tolerance of 9089 may yet be found.

Köhler (16) discussed two questions. How to maintain virus-free stocks of potato, and how to breed resistant varieties. The methods for keeping the plants free from the aphis *Myzus persicae,* the vector of the two most troublesome virus diseases, are considered. A few varieties such as Parnassia, Flava, Fenergold and Jubel show resistance to both leaf roll and streak mosaic.

As a result of field tests at Dahlem, Berlin, in 1937, Köhler (15) classified 26 potato varieties into four groups, the first comprising varieties susceptible to both leaf roll and virus, the second those susceptible to leaf roll but their reaction to virus Y is not clear, the third those susceptible to Virus Y with an uncertain reaction to leaf roll, and the fourth those with reduced susceptibility (either active resistance or tolerance) to both viruses.

Altgold, Jubel, Flava, Voran and Parnassia possessed a high degree of tolerance to leaf roll, being just as receptive to the virus as the strictly susceptible varieties but suffering little or no injury. Altgold and Jubel were highly intolerant and Parnassia moderately tolerant of virus Y The yields of Altgold, Flava, Jubel, Voran, and Parnassia remained relatively stable for three successive years, whereas those of Centifolia, Sickingen, and Stärkereiche decreased considerably, owing to infection. The yield of Voran, which showed severe symptoms of disease, compared surprisingly well with others, indicating a considerable tolerance of both viruses. It is concluded that by transgressive inheritance a much higher degree of resistance to, or even immunity from, virus Y could be obtained. It is believed also that a higher degree of tolerance of leaf roll can be obtained.

The inheritance of immunity to potato virus X found in seedling 41956 was studied by Stevenson *et al* (34) in a selfed line of this seedling, in crosses between the seedling and the varieties Katahdin and Earlaine and in two progenies obtained by selfing two immune selections from these crosses. Thirty-seven per cent of the progenies of the two crosses and from 72 to 78 per cent of the selfed lines were found to be immune. The results can be explained on the basis of autotetrasomic inheritance with two genes A and B both necessary for immunity, the immune plants studied having the formula AAaaBbbb and the susceptible plants aaaabbbb.

Late Blight Resistance

In inoculation experiments by the contact method to determine the varietal reaction of potatoes to late blight, *Phytophthora infestans,* Bordukova (3) found that in resistant varieties such as *Solanum demissum* and No. 867, the tissues are so sensitive to infection that necrosis sets in rapidly, resulting in such unfavorable conditions for the pathogen that it cannot survive. In susceptible varieties the tissues show no initial reaction to invasion, the cells dying only after the requirements of the parasite have been exhausted, at which stage the infected region is deeply permeated by the mycelium.

Reddick and Mills (30) found that certain hybrid seedling potatoes are immune to blight when the organism *Phytophthora infestans* for inoculation is taken from commercial varieties but are susceptible when a virulent culture of the organism is employed. Tests were made to determine whether a build-up of virulence might be expected under average field conditions or whether certain of the hybrids could be intro-

duced as blight-immune varieties. In 4 of the 5 tests conducted, the hybrids that were known to be immune from the organism taken from commercial varieties but susceptible when inoculated with the virulent culture eventually became affected under ordinary field conditions. It is concluded that for the present it is highly inadvisable to allow any such hybrids to exist beyond the confines of an experimental field. The conclusion is based on the assumption that the fungus would overwinter at a virulent level and would thus be in condition to initiate general infection at the first opportunity. Evidence to support the assumption is awaited.

Stevenson (33) discussed the results of field tests of late blight resistant varieties of potatoes. The importance of the time at which the epidemic develops is pointed out. Some years, as in 1933, no blight develops. Other years, such as 1937, the blight develops so late in the season that it does not decrease the yield of susceptible varieties that make their crop early. In other years, like 1938, the disease starts early and continues to spread throughout the growing season, causing severe losses.

Eight varieties were grown in plots sprayed with Bordeaux mixture and also in plots not so sprayed in 1937 and 1938. Under conditions for blight as it occurred in 1937, Green Mountain was the only one of the 8 that it would have paid to spray. In 1938, however, spraying would have been profitable on all varieties in the test. The yield data showed that Sebago was less injured in the non-sprayed plots than Green Mountain and it was shown to have the added advantage that it is much less subject to tuber rot caused by late blight than is the Green Mountain.

According to Lunden (24), in Norway as elsewhere, late blight caused by *Phytophthora infestans* is the most destructive and economically important disease of potatoes. In 1937 the crop was reduced approximately ⅓, if compared with the 5-year average, 1931-1935. In that year it is estimated that the production of the three most resistant varieties, Marius, Jubel, and Centifolia, was double that of the three most susceptible, Up-to-Date, Great Scot, and Tinwald Perfection. Some outstanding results in breeding potatoes for resistance to various diseases are summarized.

Resistance to Common Scab (*Actinomyces Scabies*)

Reddick (31) showed *Solanum commersonii, Solanum chacoense, Solanum caldasii,* var. *glabrescens, Solanum jamesii* and an unnamed form appeared to be immune to *Actinomyces scabies* in field and green-

house tests in two years. All of these have objectionable characters such as late maturity, long stolons and in the case of the first three, bitter flavor. Interspecific hybrids involving these forms have been obtained but their usefulness in the production of commercially valuable scab resistant forms has not yet been determined.

In soil inoculation tests at the Minnesota Agricultural Experiment Station, two pathogenic races of *Actinomyces scabies* were isolated and designated races 1 and 2 by Leach *et al* (21). Potato seedling 5-10-1 proved to be very susceptible to race 1 and highly resistant to race 2. Jubel was moderately susceptible to race 1, but highly resistant to race 2. The susceptibility of certain seedlings previously reported resistant is explained on the basis of these different pathogenic races. The significance of these facts in the problem of breeding for scab resistance is pointed out.

Clark *et al* (6) in a report on the inheritance of scab resistance in certain crosses and self lines give information of considerable interest to the plant breeder. Green Mountain appears to breed true for susceptibility. Katahdin is susceptible, but carries one or more genes for resistance. Hindenburg and Ostragis appear to be homozygous for resistance, whereas seedling 44537 and Richter's Jubel are heterozygous. There is a genetic linkage between resistance to scab and russeting and in one cross resistance was independent of the factors for red *vs.* white tubers. A number of highly resistant white-skin seedling varieties have been produced. Some of these approach commercial varieties in vigor and yield. There is every reason to believe that varieties can be obtained combining resistance to scab with other characters of economic importance.

Resistance to Brown Rot

Müller (26) tested 300 varieties of potatoes from Europe and America for resistance to brown rot (*Bacterium solanacearum E.F.S.*). A certain degree of resistance was shown by Green Mountain, Epicure, Arran Comrade, Koninkjes, Kentang, Djawa, Kentang Djawa (from Bali), Kentang Djawa Peotih, Botergele. As no immune variety was found, crosses of varieties *S. andigenum* and *S. antipovichii* with cultivated forms are to be made in hopes of obtaining an immune form.

Late blight, *Phytophthora infestans* (Mont.) deBary has also been recorded in Java and data on the comparative resistance of the different indigenous and other varieties grown have been collected and it is hoped

that forms resistant to the leaf and tuber injury may be found. The strain of Phytophthora involved is apparently the same as that found in Holland.

Immunity from Potato Wart

Lunden (23) in his work on immunity to the wart disease (*Solanum endobioticum*) studied the following progenies: Immune selfed, not immune selfed, immune x not immune, and reciprocal and immune x immune.

Some progenies of the immune x not immune crosses gave 1:1 ratios; others gave a larger number of immunes than not immunes. Some of the progenies of immune x immune crosses gave 3:1 immunes to not immunes; others gave more than 3 immunes to 1 not immune.

The results were explained on the basis of 3 factors: X, a dominent factor which determined immunity in simplex (Xx3) individuals. Y and Z, complementary factors. They also condition immunity in the simplex (Yy3) (Zz3) condition. Y and Z are independent of X. Not immune selfs or not immune x not immunes gave all not immune plants. Immunes selfed gave close to a 3:1 segregation of immunes to not immunes. Progenies in which Jubel were used gave variable results.

No correlations were found between immunity to wart and other characters of the potato and no variety has been found breeding true for immunity.

Drought Resistance

Differences have been observed by Demidovic (7) in time of sprouting, in rate of development of sprouts, and in the period of vine development. Pronounced differences in drought resistance have been observed. Drought resistance seems to be associated with early tuber development and with a vigorous root system. Data are given to show the rate of increase in tuber weight in the different periods for a number of varieties in wet and dry years. These again show the varieties differ in the periods in which they are most sensitive to drought. The results show that by suitable choice of varieties and agricultural operations, it is possible to grow potatoes under conditions of considerable drought. Drought resistant seedlings have been obtained from the crosses (*Solanum demissum* x Fürstenkrone) x Alma (*S. demissum* x Alma) x Granat. *S. rybinii* x *S. stentomum* and certain crosses between varieties of *Solanum tuberosum* Imperator x Hindenburg No. 4858. Some seedlings showed considerable resistance to virus, others were susceptible.

Resistance to Insects

A study was made by Allen and Rieman (1) of the resistance of a number of new and old potato varieties and segregating seedling progenies to hopperburn caused by the leaf hopper, *Empoasca fabae* Huber. Selections were found more resistant than any of the commercial varieties tested.

Emme (9) reported that according to Trowvelot certain species of Solanum show resistance to the Colorado beetle and an attempt is now in progress in the U.S.S.R. to breed a variety of potato resistant to this insect and if possible resistant also to late blight. The analysis of a number of initial crosses between Solanum species is recorded in the article. Some of the cytological results are interesting. The somatic chromosome number of all hybrids of *S. Emmeae* (2n=24) with 24 chromosome species was 24. The first and second divisions were normal, secondary pairing, however, indicating tetraploidy of the parent species. In the F_1 of Commersonii x Emmeae, 2n was about 34, which suggests that the gametes from Commersonii had probably 22 chromosomes. In the hybrids of Ajuscoense x Emmeae and Antiopoviczii x Emmeae, about 36 somatic chromosomes were found. These hybrids did not flower and showed poor development in general. In three F_1 seedlings of Commersonii x Antipovczii var. Gandarae 2n was 46 and 48 which supports the view that Commersonii produces gametes containing 22 and 24 chromosomes.

Earliness

Veselovsky (35) reports the results obtained in breeding for earliness. Some of the intervarietal *Solanum tuberosum* crosses giving early hybrids are (Cobbler x Jubel (wart immune)), Di-vernon x Cobbler, Epicure x Cobbler, Cobbler v Fürstenkrone and Epicure x Alma.

In the F_1 of the cross *Solanum andigenum* x *Solanum tuberosum*, the following characters are dominant: late maturity, fertility, ability to form tubers and a large number of tubers to the cluster. By backcrossing with early commercial varieties, a combination of the following characters has been obtained: early formation of tubers, short period of tuber development, early normal completion of the vegetative period and high productivity. Outstanding crosses are Early Rose x F_1 (*Solanum andigenum* var. taccla x Fürstenkrone) Epicure x F_1 (*Solanum andigenum* var. *tocanum* x *Centifolia*) and Early Rose x F_1 (*Solanum andigenum* var. *tocanum* x Centifolia).

Kawakami (14) reported that tubers of certain varieties of potatoes

produce sprouts more easily than others in response to treatment with ethylene chlorhydrin.

A report by Smith (32) shows that some of the South American potatoes that form few tubers in Leningrad have given quite high yields in Western Pamir. Interspecific hybrids and European varieties have given from 4 to 6 pounds per plant. These high yields are attributed partly to short day length and partly to the peculiar conditions in these high regions, all above an altitude of 6,500 feet. Some data are given on the frost resistance of South American species and hybrids.

Kawakami (13) graded the seedlings obtained from different crosses into 3 classes, A. B. C., according to their tuber color, size and eye character. The percentages of Class A seedlings obtained are given in tabular form. Deodara and Pepo gave good percentages of Class A seedlings both in crosses with other varieties and in selfings. It is considered possible to combine the quality of Deodara and Pepo with the virus resistance of Yoimo, Kintosi and Jersey Red Skin.

Flowering and Seed Setting Environment

Werner (36) reported that by growing potato plants under the coolest possible conditions and increasing the length of day to 16 hours with artificial lights, flowering and seed settings were induced and some crosses were made in Nebraska. The breeding program there has for its objective heat-resistant varieties, early varieties and a red variety that will not crack so badly at harvesting as Triumph.

Clarke and Lombard (6A) show that under conditions at Beltsville, Md., the length of day is an important factor in the production of mature flowers and fruits by various varieties of potatoes. Varieties differ in their light requirements for the production of flowers and seed balls. A greater number of flowers is produced with the longer photoperiods. In general it appears that satisfactory conditions for both flowering and fruiting were provided at Beltsville by a day length of approximating 16 hours.

Mutations

Dorst (8) reported that in the propagation by asexual means of a collection of potato bud mutants some have suddenly acquired resistance to certain diseases, *e. g.*, late blight, *Phytophthora infestans*, and common scab, *Actinomyces scabies*. Judging by the results of crossing experiments, some of these mutant characters appear to be heritable.

Kagawa (12) decapitated young plants of *Solanum gracile* and out

of 80 adventitious shoots which developed from the callus, two proved to be chromosomal chimeras consisting partly of tetraploid and partly of diploid tissue. Plants showing the tetraploid chromosome number which develop from seed collected on tetraploid parts of the chimera will, however, be true tetraploids. Pollen formation in tetraploid anthers and in a triploid plant was studied. The mean diameter of pollen of a diploid plant was 26.2, that of a triploid 27.7, and of a tetraploid 31.9 microns. Both triploid and tetraploid anthers showed multivalents at meiosis, had highly irregular anaphase separations and a high percentage of bad pollen.

Krantz and Tolaas (20) reported that the Red Warba potato arose as a periclinal chimera from the Warba. The Warba has white skin with pink eyes, the mutant is a red skin variety. Plants grown from the original mutant tuber produced tubers with patches of undifferentiated periderm which bore neither buds nor lenticels.

Graft-Hybrids

Filinnov (10) discussed various views on the relation between scion and stock with emphasis on the work and theories of Michurin and Lysenko. Instances are then cited from the author's own experiments of variations in the mode of branching, the leaves, fertility, color and structure of tubers and time of tuber formation in grafted plants, all due to interaction between scion and stock. The influence of grafts of an early variety in hastening tuber formation in a normally late variety used as stock was clearly seen in experiments with Early Rose and Wohltmann. Analogous results were obtained from 58 different combinations. The earlier the scion, the more rapidly did the stock begin to form tubers. Where wild species were grafted upon early varieties, the stock formed no tubers for 170 days, though tuber formation in the controls began 100-120 days earlier. The converse relationship was shown when the wild species were used as the stock.

The short day species *Solanum demissum* and *Solanum acaule* when Early Rose or Epicure had been grafted on to them produced large tubers 60 to 70 days after planting out and 30 to 40 days after the grafting operation while the control-grafts of wild type on wild type had formed no tubers in 200 days.

Further observations made upon plants raised from early tubers obtained as described above showed that such plants might exhibit characteristics derived from the scion as well as those from the stock and intermediate characters also occurred. In addition from the grafts of Early Rose, Epicure and Lorkh upon *Solanum demissum,* plants

totally unlike the original wild form were obtained. Some were like the original form, others intermediate in type and others showed a marked resemblance to the cultivated form. In fact, the progeny were (adopting the author's terminology), true "vegetative hybrids." Similar results were obtained by F. S. Solodoonikov in conjunction with the author. Tubers from the plants thus obtained by grafts of cultivated varieties upon *Solanum demissum* and *vice versa,* are to be used for further study and multiplication.

A recapitulation of the views of Michurin and Lysenko and their followers upon the mutability of the gene in response to environmental influences is given by Maksimovic (25). Data on intervarietal potato hybrids in the first and subsequent generations are interpreted as being in accordance with the above-mentioned views. In the author's opinion, though hybridization will continue to be of value in potato breeding, full attention must be paid to environment with special reference to providing suitable conditions for the expression of dominance of desirable characters. Moreover, the method of vegetative hybridization (grafting) must be widely applied.

The new methods advocated will necessitate individual care of plants which will be raised in relatively small numbers.

New Varieties

Odland and Cox (28) reported the work of the Rhode Island Agricultural Experiment Station done in cooperation with the Bureau of Plant Industry, U. S. D. A., in testing potato seedlings produced by the Federal Department. The seedling varieties have been compared with standard varieties in yield, disease resistance and other characters of economic importance. An aggregate of 164 lots of seed stock has been tested in replicated short rows and more than 400 smaller lots as tuber units or for special studies during the last 10-year period.

Chippewa is one of the most promising of the new varieties. It is a good yielder, produces a high percentage of marketable tubers, and is attractive in appearance. In cooking quality, however, it is somewhat less desirable than Green Mountain.

Katahdin is similar to Chippewa in length of growing season, appearance and cooking quality, but inferior in yield.

Houma is a medium maturing variety that shows promise. It has a desirable appearance, good cooking quality and gives satisfactory yields.

Golden lacked cooking quality and produced too low a percentage of U. S. No. 1 tubers.

Sebago is outstanding in blight resistance. It also seems to be resistant to scab. It is a good yielder of high quality potatoes. It is one of the most promising of the seedlings tested. The scab test indicated that a number of the seedlings in addition to the Sebago are much more resistant to scab than are the Green Mountain.

New Species

Juzepczuk (11) says that the section Tuberarium Dun. is comparable in its great size and diversity to the European genus Rosa L. A knowledge of the taxonomy is of great importance in deciding the origin of the cultivated potato, a question that has not yet been definitely settled.

The author has made an extensive study both in South America and in the collection grown in Leningrad of a great number of forms belonging to species hitherto undescribed.

A need for descriptions of some of these species already widely known in genetics and cytology has been felt, in order to legalize the names according to international rules. Latin descriptions of 21 species are given herewith with discussions on their affinities.

Progress in Potato Breeding

Krantz (17) briefly reviewed the early work in potato breeding in the U. S. A. After the introduction of the Rural type in 1886 there followed a period of nearly 50 years in which no variety of any importance was introduced. The present activity in this country is attributed to the development of fertile breeding stocks by the United States Department of Agriculture and the Minnesota Agricultural Experiment Station. The varieties so far produced are Katahdin, Chippewa, Warba, Golden and Houma and the first three are already proving popular. Golden and Houma are of too recent introduction to estimate their popularity.

Krantz (18) as retiring President of the Potato Association of America at its 25th annual meeting held in Richmond, Va., gave an address in which he reviewed some of the work done in potato investigations during the quarter century the Association had been in existence. He emphasized the work by Dr. William Stuart in Vermont and later continued with the U.S.D.A. He referred to some of the recent contributions and new varieties that did much to reawaken interest in potato breeding throughout the United States and called attention to the fact "that the inherent possibilities for improvement in the cultivated varieties have been barely touched."

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THE EFFECT OF PSYLLID INJURY ON THE VIGOR OF SEED POTATOES

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Psyllid yellows was first described by Richards in 1927. It is one of the most serious maladies affecting potatoes in the Rocky Mountain region and adjoining states, and is produced by a tiny insect known as the potato or tomato psyllid.

In order to determine the effect of psyllid injury on the vigor of seed potatoes, studies were conducted in 1939, using seed tubers that had been produced the previous season on plants showing a wide range of psyllid yellows symptoms. In 1938 the variety Triumph was planted at Greeley and at Estes Park. In each location one series of plots was sprayed and one unsprayed. One gallon of liquid lime sulphur was mixed with forty gallons of water. The sprayed plots at Greeley were power-sprayed three times, using 450 pounds pressure. The plants and tubers developed normally, giving no indication of psyllid yellows and producing 360 bushels of U. S. No. 1 tubers on each acre. The unsprayed plots at Greeley produced a normal set of tubers, but the plants developed medium severe vine injury, producing only 190 bushels per acre of U. S. No. 1 tubers.

The sprayed plots at Estes Park received two applications. Traction equipment was used which developed about 250 pounds pressure. A large population of psyllids was present at Estes Park, resulting in severe vine injury and although there was a fairly normal set of tubers in the sprayed plots, the yield was very low. The unsprayed plots at

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Estes Park were very heavily infested with psyllids, several hundred nymphs being found per plant. Vine injury was very severe and on each plant a large number of tubers was set, all of which were small at time of harvest.

In seasons when psyllid injury occurs in the Rocky Mountain region, these insects are usually more abundant in the mountainous area than in the prairie area. This was especially true during the season of 1938.

All the plots were harvested during the last week of September. Tubers weighing from 1¼ to 1½ ounces were selected for planting the test plot the following year. These were stored in the potato house at Greeley until the first of April, then placed in cold storage until the first of June. The tubers from the unsprayed plants at Estes Park began to sprout in November. On December 10, the sprouts were removed. There was also some sprouting of the tubers from the sprayed plats at Estes Park. The sprouts were again removed when the tubers were placed in cold storage on the first of April. Tubers from the unsprayed plots had the most sprouts and the longest. The rest period appeared to be broken entirely,—soon after harvest; there was no apical dominance and the sprouts were rather weak. The tubers from the sprayed and unsprayed plots at Greeley gave no evidence of sprouting at the time the seed was placed in cold storage.

Plantings to test the vigor of the seed tubers were made at Greeley on the 12th of June. Each plot was a single row planted with thirty whole tubers spaced fourteen inches apart in the row. There were eight blocks and the plots were randomized in each block.

TABLE 1.—*Behavior of potatoes grown at Greeley, Colorado, from plants that showed different degrees of psyllid injury,* 1939

Degree of Psyllid Injury on Parent Vines	Hills per Plot*	Stems per Hill	Height of Plant	Diameter of Stem	Yield per Plot U.S. No. 1
	No.	No.	Cm.	Mm.	Lbs.
No vine injury	29.8	3.8	58.5	13.3	63.8
Medium severe vine injury	29.4	3.8	54.2	12.4	58.0
Severe vine injury	26.4	5.0	51.8	11.3	37.1
Very severe vine injury	26.9	4.3	44.5	9.4	29.0
Difference required for significance	1.5	0.56	2.2	0.45	5.0

*Thirty whole tubers planted per plot.

Plots planted with seed tubers from sprayed and unsprayed plants at Greeley are designated as "No vine injury" and "Medium severe vine injury," and those planted with seed tubers from sprayed and unsprayed plants at Estes Park are designated "Severe vine injury" and "Very severe vine injury" as you will note in table 1.

The plants in all plots were carefully examined during the summer of 1939, but no evidence was found of any disease carried by the seed tubers that could be connected in any way with psyllid yellows.

The mean stand in the no vine injury plot was 99.1 per cent; medium severe vine injury, 97.9; severe vine injury, 87.9; and very severely injured plots 89.6 per cent. The seed pieces that failed to produce plants were found to be dormant. Seed pieces from plants having severe and very severe vine injury produced a significantly lower stand than seed pieces from vines showing medium severe or no injury.

The analysis of variance shows that the difference in number of stems per plant is significant but not highly so. The size of the plant was determined by measuring the height and diameter of the largest stem. The diameter of the stem was measured about one inch above the surface of the ground. The largest plants were in the no vine injury plots. The smallest plants both as to height and thickness of stem were produced from the seed of plants that were very heavily affected by psyllid yellows as shown in table 1. Many of the stems were weak and decumbent. There was also much irregularity in the size of the plants.

Plots were harvested on the 25th of September and the tubers graded and weighed. Where vines were uninjured the plots gave the largest yield, and the production decreased significantly with increasing severity of injury to seed parents.

These studies indicate that seed tubers produced from plants showing medium severe vine injury may produce good yields but that tubers produced from plants showing severe vine injury do not. One year's results, however, should not be taken as positive proof that medium heavy vine infection has little effect on vigor of seed. These tests cannot be repeated in 1940, because of the light infestation of psyllids in 1939 on the seed plots and throughout the Rocky Mountain region. Plans are being made to repeat these tests when psyllids appear on the plants in sufficient numbers to cause severe yellowing.

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EXPERIMENTAL WORK FOR THE CONTROL OF RING-ROT OF POTATOES

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I. RELATIVE EFFICIENCY OF POTATO DISINFECTANTS IN THE CONTROL OF RING-ROT SPREAD THROUGH THE CUTTING KNIFE.

A. Disinfectants used: (1) Lysol (2½ tablespoons to 1 gallon of water); (2) Lysol (1¼ tablespoons to 1 gallon of water); (3) Corrosive sublimate (1:1000); (4) Corrosive sublimate (1:500); (5) Formaldehyde 40 per cent (full strength); (6) Formaldehyde (1:10); (7) Formaldehyde (1:50); (8) Formaldehyde (1:100); (9) Semesan Bel (recommended strength); (10) Cinnex-20 (Mercuric oxide 20 per cent, Phenol 1 per cent) (recommended strength); (11) Mercurnol (commercial acid-mercury) (recommended strength); (12) Acid-formaldehyde (formaldehyde 1:120 plus 1 per cent muriatic acid); (13) Control (disinfection, no inoculation); (14) Control (inoculation, no disinfection).

B. Procedure: A healthy lot of seed was used. The cutting knife was then drawn through a ring-rot infected tuber, after which it was placed in disinfecting solution for approximately 5 seconds. It was then removed and used to cut healthy tubers in half. This procedure was repeated with 20 tubers for each lot. One-half of each tuber was planted soon after being cut, while the other one-half was allowed to heal over for two days before being planted. The plants were checked for ring-rot symptoms on the 10th and 24th of August, and a final check was made on the 30th of September by digging each hill separately and cutting all the tubers for ring-rot symptoms. The results are shown in table 1.

Using the short disinfection period of approximately 5 seconds, corrosive sublimate was the most efficient material used in the test. It almost completely eliminated ring-rot spread by the cutting knife, whereas others failed to do so in that period of time. Mercurnol was not quite so efficient as corrosive sublimate.

On the 10th of August only 10 per cent of the total plants showed ring-rot symptoms, whereas on the 24th, 40 per cent of them showed infection. At digging time, on

the 30th of September, about 60 per cent of the hills showed ring-rot symptoms in the tubers.

There was very little difference in ring-rot prevalence between lots planted soon after cutting and those planted two days after cutting.

II. The Effect of Treating a Ring-rot Lot of Seed before and after Cutting.

A. This lot of seed showed 18-20 per cent of visible ring-rot symptoms.

B. The treatments used and length of treatment are as follows: (1) Hot formaldehyde—3 minutes; (2) Cinnex 20—10 minutes; (3) Mercurnol—10 minutes; (4) Semesan Bel —1 minute; (5) Non-treated control; (6) Lysol (1¼ tablespoons to 1 gallon of water) used as a treatment after cutting—10 minutes.

C. The tubers were planted with 3 replications—each replication having a row of 20 hills. The stand and total yield data were taken, as well as ring-rot prevalence, on the 24th of August and on the 30th of September at harvest time. These results are shown in table 2.

The differences in stand between treatments did not vary significantly. In yield, Mercurnol was highest, significantly so, in lots treated before cutting but not in those treated after cutting. Similarly, Mercurnol was best in the control of ring-rot, being significantly better than the other treatments in the final check-up in lots treated before cutting, although the difference was not quite significant in lots treated after cutting.

The differences in ring-rot percentages in lots "treated before cutting" and in those "treated after cutting" are highly significant.

III. Whole-seed *versus* Cut-seed and Resulting Ring-rot.

Whole tubers, 85 in number, from a ring-rot lot of seed and an equal number of cut seed pieces from the same lot of seed were planted for comparison. The whole seed resulted in 23 per cent, whereas the cut seed showed ring-rot in 72 per cent of the plants.

IV. Results of Selecting Healthy-appearing Tubers from a Ring-rot Lot of Seed.

From this lot of seed, 115 tubers that showed no discoloration whatsoever and appeared to be free from ring-

TABLE 1.—*Solutions used to disinfect the cutting knife and their efficiency in the control of ring-rot spread*

PER CENT OF RING-ROT ON DATES CHECKED

Disinfectant	Aug. 10 (Plant Symptoms)		August 24 (Plant Symptoms)		September 30 (Tuber Symptoms—% of Hills		
	Planted June 1	June 3	Planted June 1	June 3	Planted June 1	June 3	Infected)
Lysol	5.3	5.0	15.8	5.0	17.6	57.9	
Lysol ½	16.7	0.0	77.8	60.0	100.0	86.7	
Formaldehyde (40%)	0.0	0.0	11.8	16.7	37.5	84.2	
Formaldehyde 1:10	25.0	10 0	65.0	50.0	85.0	78.9	
Formaldehyde 1:50	26.3	11.1	89.5	66.7	100.0	82.3	
Formaldehyde 1:100	40.0	35.0	90.0	70.0	89.5	88.9	
Cinnex—20	10.5	16.7	68.4	61.1	93.7	93.7	
Semesan Bel	0.0	15.0	60.0	60.0	89.5	70.6	
Acid-formaldehyde	0.0	21.0	38.0	47.4	65.0	88.9	
Mercurnol	0 0	5.0	5.0	10.0	20.0	21.4	
(1) $HgCl_2$ 1:1000	0.0	—	5.0	—	5.0	—	
(1) $HgCl_2$ 1:1000	0.0	—	0.0	—	0.0	—	
$Hg\ Cl_2$ 1:500	0 0	0.0	0 ?	0.0	0.0	0.0?	
Control No inoculation	0.0	0.0	0 ?	0.0	0 0	0.0?	
Control No disinfection	—(2)	—	94.7	—	97.7	—	
Average (12)	10.3	9.9	43.5	37.2	58.1	62.8	

(1) Both lots planted on the 1st of June (by mistake) thus none was planted on the 3d of June.
(2) Data missing.

(2) Both lots planted on the 1st of June (by mistake) thus none was planted on the 3d of June.

TABLE 2.—*Seed treatment experiment with a ring-rot lot of Bliss Triumph potatoes treated before and after cutting. Three replications.*

Treatment	Average Per Cent Stand		Average Total Yield in Pounds		Percentage of Plants Showing Ring-Rot August 24		Percentage of Hills Showing Ring-Rot When Dug—Sept. 30	
	Treated before Cutting	Treated after Cutting	Treated before Cutting	Treated after Cutting	Treated before Cutting	Treated after Cutting	Treated before Cutting	Treated after Cutting
Hot Formaldehyde	91.5	85.0	8.5	8.5	52.5	25.4	78.1	42.2
Cinnex—20	93.0	88.0	8.1	8.2	51.1	34.0	77.5	53.7
Mercurnol	100.0	88.0	12.8	9.7	21.7	15.3	35.8	21.5
Semesan Bel	98.0	91.5	8.4	8.3	48.8	16.6	69.5	38.4
Lysol		93.0		7.3		37.1		65.9
Control	95.0		7.2		49.6		82.4	
Average—First 4 Treatments	95.6	88.1	9.4	8.7	43.5	22.8	65.2	40.4
Difference required for significance (5% point)	a	a	2.2	2.3	30.2	24.9	26.0	24.3

a—The F value was smaller than that necessary to give a P of .05.

rot infection were selected. Each tuber was clipped at the stem end for visible symptoms and the knife disinfected between each tuber cut. Slightly more than 30 per cent of these resulting plants were infected with ring-rot.

From this same lot of seed, 67 tubers were selected showing only slight yellowish discoloration in the vascular area or what appeared to be slight ring-rot infection. Of the resulting plants, 85 per cent were infected with ring-rot.

V. THE AMOUNT OF SPREAD OF RING-ROT INFECTION BY THE CUTTING KNIFE.

A healthy lot of seed was used, as determined by the controls. The cutting knife was drawn through a badly infected tuber and subsequently used to cut 10 healthy ones. One-half of the tuber was planted soon after cutting, and the other one-half left to heal over for 2 days before planting. This procedure was repeated 5 times with 10-tuber lots. The order of tubers cut was noted and the seed pieces were then planted in consecutive order in the rows. Infection occurred in practically all of the tubers cut and was as prevalent in the 10th hill as it was in any of the others.

VI. SPREAD OF RING-ROT BY CONTACT OF TUBERS.

A healthy lot of large tubers was used in this test. This lot was selected on the basis of sound, unbroken skin between eyes, located rather far apart. Such an area of sound skin and the two adjacent eyes were smeared with inoculum from a naturally-infected tuber. Each tuber was cut in halves, one half being planted with the ring-rot inoculum and the other one-half as the control in an adjacent plot. Forty such tubers were selected, inoculated and planted. More than 40 per cent of the resulting plants developed ring-rot. Ten tubers were used similarly but inoculated only on the sound skin between two eyes—widely spaced. No ring-rot developed in any of these plants, neither was any evident in the tubers. Therefore, it appears that the ring-rot infection must have occurred through the eyes of the tubers.

A STUDY OF SEEDLINGS AND VARIETIES OF THE IRISH POTATO IN CUBA

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A large number of seedlings and varieties were introduced to form an experimental stock. It has been observed in a three-year period that most of these seedlings that have been introduced as well as those produced in Cuba did not show so much vigor as they usually show in their original home environment; in other words, a lowering of vigor was observed.

Limiting Factors.—Virus diseases and climatic influences were found to be directly responsible for such degeneration or running out.

Table 1 shows that any seedling or variety artificially inoculated by mosaic virus was unable to produce number 1 size potatoes. From thirty-seven artificially inoculated seedlings, seven produced No. 1's, fourteen produced only No. 3's, and one did not produce any potatoes at all.

This shows the importance that virus diseases have in the production of potato seed in Cuba. There are two different methods known by which we can control such effect: first, selection of resistant varieties, and production of immune ones; and second, selection of disease-free plants and roguing of diseased ones.

Usually virus diseases are responsible for the low yield obtained by growers when they attempt to use home-grown seed. This fact is clearly understood when one finds that no roguing has been carried out and that culls are used for seed purposes.

From the foregoing it seems that by roguing it is possible to keep a healthy and vigorous stock, but actual results obtained in a three-year period do not show this to be true. A marked loss of vigor and a reduction of yield were observed at the end of the third year regardless of how strictly roguing was conducted. Nevertheless, good yields were obtained the second year. This seems to indicate that the length of day is also directly responsible for such degeneration, since the wild varieties from short-day areas of South America did not lose any vigor at all.

Performance of German Varieties.—No scab lesions were observed in any of the German varieties. This may be due to the fact that potato seeds were treated with mercuric bichloride and that they were planted in new, fresh land. There were only two, the Carnea and Ackersegen varieties showing some silver scurf.

TABLE 1.—*Inoculated Mosaic*

Variety	Germination	No. 3	No 2	No 1	Fancy No. 1	Total	(*) Average	Average in Pounds Pounds	Ounces
Red Bliss Triumph	255	176	352	448	176	1152	451	28	3
Red Bliss Triumph	28	16	24	32	—	72	257	16	1
Chippewa	4	8	2	2	—	12	300	18	12
Ackersegen	3	8	—	—	—	8	266	16	10
Michigan Red	34	12	—	—	—	12	35	2	3
Krantz R.S.R.F	13	8	—	—	—	8	61	3	13
Krantz P.S.P.F.	4	4	—	—	—	4	100	6	4
164-125 Rep. 2	11	13	—	—	—	13	118	7	6
164-125 Rep. 3	6	5	—	—	—	5	83	5	3
164-126 Rep. 3	19	48	30	4	—	82	431	26	15
164-72	6	3	—	—	—	3	50	3	2
TK 1-11-1	1	2	—	—	—	2	200	12	8
1-7-2	3	2	4	—	—	6	200	12	8
1-14-92	1	1	5	—	—	6	600	37	8
1-53-4	4	6	25	3	—	34	850	53	2
3-1-2	3	2	—	—	—	2	66	4	2
3-23-21	27	16	22	14	—	52	192	12	0
1-31-7	8	20	5	—	—	25	312	10	8
3-6-1	6	4	2	—	—	6	100	6	4
3-53-43	2	2	2	—	—	4	200	12	8
3-57-47	5	9	—	—	—	9	180	11	4
TKK 1-10	12	24	18	8	—	50	416	26	0
1-11	3	1	3	—	—	4	133	8	5
Mc K 2-2	1	2	3	—	—	5	500	31	4

TABLE 2.—*Performance of German varieties*

	SKIN COLOR	FLESH COLOR	LIFE CYCLE	FLOWERING IN CUBA	DISEASE RESISTANCE TESTED OUTSIDE OF CUBA
ALMA	White	White	Early	Yes	Phytophthora
DUKE OF YORK	White	Yellowish	Early	No	
CENTIFOLIA	Red	White	Medium	Yes	
BINTGE	Yellow	Yellowish	Medium	No	
ROSAFOLIA	Light Red	White	Medium	No	Wart
ALLERFRUHESTE GELBE	White	Yellow	Medium	No	
ODEWALDER BLAUE	Purple	Yellow	Medium	No	
ROYAL KIDNEY	White	White	Medium	No	
WELTWUNDER	Light Red	White	Medium	No	
CARNEA	Red	White	Late	Yes	Wart, Phytophthora, Scab
ACKERSEGEN	White	Yellowish	Late	No	
OVALGELBE	White	Yellow	Late	No	Wart
APOLIA	Yellow	Yellow	Late	No	Wart
HINDERBURG	White	White	Late	Yes	Wart
INDUSTRIA	White	Yellowish	Late	Yes	
JUBEL	White	White	Late	No	Wart and Scab
HETMAN	White	White	Late	No	Wart
GLORIA	Yellow	Yellow	Late	Yes	

TABLE 3.—*German variety behavior*

	Germination	Fancy No. 1	No. 1	No. 2	No. 3	Total	Average	Mosaic	Blight	Remarks
Centifolia	118	8-6	50-0	40.0	8-0	106-6	89.83	6.340	5	
Ovalgelbe	67	27-0	36-0	26-0	8-0	97	144.77	27.95	1	
Carnea	102	15-8	50-8	31-0	7-0	104	101.96	6.42	0	Some silver scurf
Ackersegen	85	10-0	44-0	31-0	6-3	91-3	86.66	13.72	0	Some silver scurf
Bintje	108	2-4	28-8	38-0	17-0	85-12	79.62	5.26	5	
Rosafolia	78	0-5	17-0	40-8	8-8	66-5	84.61	13.33	5	
Apolia	92	7-2	37-0	29-0	0-0	82-2	89.13	10.81	2	
Alma	75	13-6	27-0	10-0	2-4	52-10	70.66	1.94	4	
Hinderburg	78	6-4	34-0	17-8	5-2	62-14	80.76	1.08	1	
Industria	76	8-4	28-14	19-0	8-8	64-10	85.52	2.29	2	
Allerfr. Gelb	81	1-6	26-0	28-0	7-12	63-2	77.77	11.20	5	
Jubel	35	8-0	22-0	16-0	3-12	49-2	140	37.50	5	
Odenw. Blaue	96	6-0	22-7	30-0	11-14	70-5	72.91	1.03	5	
Royal Kidney	85	—	2-8	22-0	21-8	46	54.11	8.60	5	
Hetman	27	0-4	1-4	2-8	21-8	25-8	96.29	40.27	5	
Weltwunder	34	2-8	9-0	8-0	2-2	21-10	64.70	1.85	5	
Duke of York	23	1-0	6-0	7-0	3-3	17-3	73.91	72.98	5	
Gloria	21	—	5-3	5-6	1-10	12-3	57.14	44.20	1	

Yield is given in pounds; mosaic in percentages; and for Blight a scale is used in which 0 is the most resistant, and 5 the most susceptible.

With reference to Blight resistance Carnea and Ackersegen proved to be the most resistant, followed by Ovalgelbe, Henderson and Gloria, then Apolia and Industria. The following proved to be very susceptible: Centifolia, Bintje, Rosafolia, Allernfrugeste Gelbe, Jubel, Odenwalder Blaue, Royal Kidney, Hetman, Weltwunder and Duke of York. Alma, Hinderburg, Odenwalder Blaue and Weltwunder showed some resistance to mosaic infection as indicated by their mosaic percentage. Duke of York, Gloria Hetman, and Jubel were the most susceptible. Alma Hinderburg, Carnea Centifolia, Industria and Gloria produced flowers.

Alma seems to be self-fertile as only two settings were obtained and these were from self-fertilized flowers. No setting was obtained by crossing it with Ackersegen, Chacoense and Caldesii pollen.

The Ackersegen variety was self-fertilized and also crossed with Alma, Chacoense and Caldesii, and although some fruits were observed they fell before harvesting.

Wild Varieties.—The importance and value of South American wild potatoes is very great for any breeding project to be developed in Cuba. Those varieties are a good source of new genes to be added to actual varieties which have lost them by more or less intensive self-fertilization and selection toward a predetermined type. In other words, such genes and characters which may be harmful for the production of a variety to be grown in North American or European climates may be of great value for the increase of yield, for the increase of resistance to certain diseases, etc., in a tropical country such as Cuba.

With reference to those wild potatoes it can be said that one of the main differences with cultivated ones is the way in which they react to length of day. Most of the South American wild potatoes are more adapted to nine or ten-hour day length condition, whereas cultivated varieties are better adapted to a thirteen-hour-day length or more.

With reference to the usefulness of wild potatoes in breeding projects it has been stated by many breeders from Russia, Germany, England, United States of America, etc., that a great deal of resistance could be communicated to their stocks by using them but the most troublesome problem found by them was the difficulty of eliminating the short-day length character that such varieties possessed.

It seems to be that although this character is troubling the growers in the northern countries, it is an enviable one for the improvement of potatoes for tropical countries.

From all the imported wild varieties, the Chacoense, Caldesii and Commersonii seem to be best adapted to Cuban environmental conditions.

THE NON-VOLATILE ACIDS OF THE POTATO[1]

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As a continuation of previous work on the non-volatile acids present in fruits and vegetables, we have investigated the non-volatile acids of the potato tuber. Though previous investigations have been made of the potato acids (1, 2, 3, 4, 5)indicating the presence of citric, malic and oxalic acids, it seemed desirable to utilize the ester distillation method as outlined by Franzen and Helwert (6) and later by Nelson (7, 8).

By this method we found citric and malic acids in a proportion of about 20 to 1 and a very small quantity of isocitric acid. Using the Arbenz (8) method for oxalic acid, 0.02 per cent of that acid was found in the expressed juice.

Experimental

Fifteen liters of juice were expressed from 23 kilograms of Maine potatoes, var. Green Mountain.[2] The acids were precipitated as lead salts, and the acids, recovered from the lead precipitate, were converted into the ethyl esters. The crude esters (92.7 gms), were fractionally distilled at 10 mm. and the following fractions collected:

1. 106-23°—1.0 gm.
2. 123-37° 2.5 (gms)-^{oc}D-10.8°
3. 168-9°—72.3 gms.
4. 169-72°—7.6 gms.

Hydrazides were prepared from these fractions. Their melting points were:

Fr. 1, Hydrazide M.P. 175-6°; mixed with *l*-malic hydrazide, M.P. 178-9°

Fr. 2, Hydrazide M.P. 178-9°; mixed with *l*-malic hydrazide, M.P. 178-9°

Fr. 3, Hydrazide M.P. 106°; mixed with citric hydrazide, M.P. 106°

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[2]The variety was identified by Dr. C. F. Clark, Bureau of Plant Industry, U. S. Department of Agriculture.

Fr. 4, gave an immediate ppt. of a hydrazide melting at 172-3°. When mixed with isocitric hydrazide it melted at 173-4°; it was identified as isocitric hydrazide by optical crystallographic examination.[3] The amount of this hydrazide was small, and the filtrate, on standing, deposited a hydrazide melting at 93-6°, evidently impure citric hydrazide.

Therefore, fractions 1 and 2 appear to be nearly pure ethyl-*l*-malate; fraction 3, practically pure ethyl citrate; and fraction 4, mainly ethyl citrate with some ethyl isocitrate. The total weights of ethyl malate and ethyl citrate were about 3.5 and 79 gms. respectively, corresponding to 0.017 and 0.37 gms. per 100 ml. of potato juice. The yields of esters were not quantitative, however.

The determination of oxalic acid was carried out as follows: One hundred millileters of potato juice were mixed with an equal volume of alcohol, the precipitate filtered and washed, and the filtrate evaporated to approximately 25 milliliters. Five milliliters of HCl were added, and the solution extracted over night with ether in a continuous extraction apparatus. The ether extract contained 0.0205 gms. of oxalic acid (weight of CaO, 0.0128 gms.). The calcium oxalate from a similar experiment was identified by optical crystallographic examination as hydrated calcium oxalate.

SUMMARY

The non-volatile acids of the juice of the potato tuber, *Solanum tuberosum*, L. (var. Green Mountain), were investigated. The ester distillation method revealed the presence of the citric and *l*-malic acids in the ratio of nearly 20:1 together with a small amount of isocitric acid. By the Arbenz method, 0.02 per cent of oxalic acid was shown to be present.

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BIOCHEMICAL AND ANATOMICAL PROPERTIES OF STARCH OF DIFFERENT VARIETIES OF POTATOES AND THEIR IMPORTANCE FOR INDUSTRIAL PURPOSES

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Problems of varietal biochemistry are of particular importance for practical selection work. When applied to potatoes, biochemical investigations should be mainly directed towards the establishment of methods for estimating varietal variability particularly as regards the quantity and quality of starch, which represents the principal and predominant substance in a tuber. However, the correct and successful determination of the methods to be used in estimating the quality of starch seems to be achievable only on the basis of a knowledge of its chemical nature and of the dependence of the various properties of starch on the physical and physical-chemical peculiarities in its structure.

The attention of investigators has until now been directed towards the determination of the nature of starch, without regarding its varietal origin.

Careful anatomical studies of the starch grain in potatoes of various varieties and species have revealed important morphological differences. The papers by Nerling (1930), Pigulevsky, Nassonov, Demidovich, Shekaev, Yakovlev, Veselovsky, and Kameraz, have shown that the qualitative composition of potato starch, *i. e.* the percentage of small and large grains in it, is a varietal character. Potato starch grains may be characterized as spherocrystals oval in shape with a regular outline and distinct lamellate structure.

Some intraspecific and interspecific hybrids of the potatoes *Solanum andigenum* Juz. and Buk x *S. tuberosum L.* as well as those of the reciprocal cross have starch spherocrystals polygonal in shape, and remarkable for their lustre.

The size of a strach grain* is, in general, a character of great importance, in determining its quality. In technological processes large grain potato starch is easily separated and rapidly precipitated. It also displays a fine lustre. According to Islentjev (5), large grain potato starch may be readily converted into soluble starch valuable as a component in the sizing of the warp of fabrics in the textile industry.

Large grain starch is the best for producing high grade paper and cinema film. It also hydrolyzes more rapidly and better than small grain starch, which circumstance is of importance both for food and distillation. Finally, the higher the percentage of large grains, the brighter and more lustrous is the farina obtained from potato starch. After we (Yakovlev, Veselovsky, Kameraz) had analysed about two hundred different potato varieties and established indubitable differences in the size and shape of their starch grains, it was quite natural to suppose that the biochemical properties of chemically pure starches of various varieties and species of potatoes were also dissimilar.

For the purpose of testing the above supposition, we selected sixty-nine varieties and species of potatoes that differed most markedly not only in their morphological characters, but also in their origin and physiological characters. Thus, we chose samples of the species *S. tuberosum*, our own selections now widely spread among Soviet and collective farms, the latest selections being of interest because of their large starch grains and early ripening, also took representatives of the South American polymorphous species *S. andigenum* Juz. and Buk. exported from South America by our Soviet expeditions and our new interspecific hybrids *S. tuberosum* x *S. andigenum*.

Our investigations conducted at the enzymatic laboratory of the All-Union Institute for Plant Growing have shown that chemically pure potato starches from different varieties and species are dissimilar in some of their biochemical properties.

The analysis of the chemically pure starches of the varieties selected have shown a positive correlation between ash content, phosphorus content and viscosity, *i. e.* the higher the ash content, the higher the phosphorus, and the greater the viscosity of the paste (table 1).

The highest viscosity is to be found in the various forms of *S. andigenum* Juz. and Buk. and their hybrids, while the lowest is present in *S. rybinii* Juz. and Buk., Grenzmark, etc.

Our analyses have shown that there are marked differences in the ash and phosphorous content between varieties, for instance: Grenz-

*Grains are to be considered large when their size is 60 microns and above.

TABLE 1.—*Starch viscosity in various potato varieties and species* (1938)

Laboratory No.	Variety or Species	Percentage of Ash	Percentage of Phosphorus	Relative Viscosity*
54	Grenzmark	0.147	0.063	4.1
64	*S. rybinii*	0.183	0.068	4.1
2	Maercker	0.218	0.069	4.2
51	Shgerkeragis	0.213	0.069	4.9
10	Kalitenetz	0.200	0.070	6.4
1	Hero	0.262	0.073	6.5
12	Popular—(Narodny)	0.219	0.075	6.2
40	Wohltmann	0.239	0.077	6.9
29	Early Rose	0.240	0.077	6.8
68	Fürstenkrone (Smyslovsky)	0.289	0.079	7.1
23	Irish Cobbler	0.261	0.080	7.1
42	Witchhill	0.220	0.082	6.8
49	Polar Rose	0.274	0.085	7.4
41	Switez	0.270	0.086	8.5
25	Epicure	0.221	0.087	8.5
46	478/99 *S. andigenum* v. *Herrerae* x Centifolia	0.310	0.090	10.0
4	Korenevsky	0.309	0.091	6.2
44	Great Scot	0.300	0.094	10.0
24	Epron	0.299	0.103	12.0
58	Saami	0.321	0.105	12.0
67	*S. andigenum* v. *Herrerae*	0.333	0.104	12.3
47	Khibin Bilberry (Khibinskaia Tchernitchka)	0.340	0.110	12.6
65	*S. andigenum* v. *quechuanum* (Taccla)	0.387	0.111	12.8
48	Katahdin	0.381	0.115	12.9
66	*S. andigenum* f. *tocanum*	0.361	0.124	14.1

*Determined by use of Oswald's viscosimeter, comparing a solution made of 0.3 per cent starch with water.

mark contains 0.147 per cent ash and 0.063 per cent phosphorous, whereas in Veselovsky's new variety Epron, there is 0.299 per cent ash and 0.103 per cent phosphorus. The English variety Great Scot has 0.300 per cent ash and 0.094 per cent phosphorus.

The South American Andean forms have still greater amounts of ash and phosphorus. Thus, Tocanum contains 0.361 per cent ash and 0.124 per cent phosphorus, whereas that of Taccla is 0.387, and 0.111 per cent, respectively.

Accompanying the variation in ash and phosphorus, the difference in viscosity was also considerable. Grenzmark has a viscosity of 4.1 and Tocanum—14.1.

Starches from different potato varieties were analyzed for nitrogen by the micro-Kjeldahl method and were found to differ in their nitrogen content. The lowest nitrogen content, 0.022 per cent, was recorded in the variety Pepo, and the highest, 0.067 per cent, in Silesia.

Interesting results have been obtained from the acid hydrolysis of the starches, definite differences having been found in their rate of hydrolysis.

A direct relation between size of starch grains and rate of hydrolysis has been established, *viz*: the larger the starch grains, the more rapid the hydrolysis (table 2).

For the purpose of investigating the adhesive properties of chemically pure starches of various origin, we collaborated with the Central Chemical Laboratory of the Leningrad cotton industry, and there used our starches (18 samples) for finishing calico.

First grade unfinished calico, *i. e.* without being first impregnated with paste, was obtained from the Khalturin factory.

Calico strips were finished with 4 per cent paste of chemically pure starch from each of the varieties mentioned. Then they were subjected to uniform pressing in a calender.

Later, we used another laboratory, that of the Chief Administration of the Leningrad cotton industry, for testing fabrics as to their strength and stretch. The laboratory made the analysis of the calico finished with our starches by means of Schopper's dynamometer.

The finished strips of fabric of definite size were pressed between the clamps D and M. The strength of the fabric was determined according to the readings on the lower dial M, while its stretch was determined according to those on the upper dial K.

The results showed that the strongest fabric was the one finished with starch from a primitive potato species, *S. rybinii*. Next was the fabric impregnated with starch obtained from the variety Katahdin. None of the remaining sixteen varieties excelled in their adhesive properties.

The fabric finished with starch from the South American Andean potato Taccla was particularly excellent as to the stretching capacity of its fibres.

The standard deviation was calculated according to the formula:

$$\sigma = \sqrt{\frac{\Sigma x^2}{n-1}}$$

n — represents the number of experiments made with each starch sort.

TABLE 2.—*Acid hydrolysis of starch from potatoes of different varieties and species* (1938)

Laboratory No.	Variety or Species	Percentage of Starch Hydrolyzed after 65 Minutes in Boiling Water Bath	Size of Starch Grains
48	Katahdin	47	Small.
64	*S. rybinii*	47	—
47	Khibin Bilberry*—Khibinskaia. Tchernitchaka	47	—
56	Umptek*	47	Small, & middle-sized.
57	Marmikve	48	Small & large.
14	Doon Pearl	48	Large
6	Elf Umpteka	48	Middle-sized & small.
3	Silesia	48	Middle-sized & large.
69	7/2 F_1 Epicure x *S. andigenum* f. *tocanum*	48	Same.
58	Saami*	48	Small.
12	Popular—(Narodny)	48	—
17	Blaupunkt	49	Small.
49	Polar Rose*	49	Middle-size C.
44	Great Scot	49	Small.
1	Hero	49	Large.
5	Lorh	49	Large.
41	Switez	49	—
46	478/99 F_1 *S. andigenum* v. *herrerae* x Centifolia	49	Small & large.
68	Fürstenkrone (Smyslovsky)	49	Middle-size & large.
24	Epron*	50	Small.
25	Epicure	50	Middle-size & large.
8	Arran Banner	50	Middle-size.
10	Kalitinez	50	Large.
63	Alma	51	—
13	Rhenoragis	51	Very large.
23	Irish Cobbler	51	Middle-size & large.
67	*S. andigenum* v. *herrerae*	51	—
7	Ustbez*	51	Middle-size.
2	Maercker	51	—
9	Deodara	51	—
65	*S. andigenum* v. *quechuanum* (Taccla)	51	—
40	Wohltmann	51	Small & large.
29	Early Rose	52	Large.
62	Komsomeletz*	52	Large.
4	Korenevsky	52	Middle-size & large.
45	316/81 F_4 Fürstenkrone x. *S. andigenum f. tocanum*	52	Large.
66	*S. andigenum f. tocanum*	53	Large.
42	Witchhill	53	Very large.
51	Stärkeragis	53	Very large.

*Potato hybrids of I. A. and M. N. Veselovsky's selection, see Appendix.

M — the common mean value (strength and stretch).
m — the error.

$$Mo = \frac{\Sigma M}{n}$$

Then σ the standard deviation of different M values from Mo was calculated according to the formula:

$$\sigma_0 = \sqrt{\frac{\Sigma D^2}{n-1}}$$

where D represents the difference between M and M o,
m_0 — the mean error of Mo, after the formula:

$$m\,o = \sqrt{\frac{\Sigma m^2}{n}}$$

After that there were established three main group limits:

$Mo - \frac{1}{2}\,\sigma_0$; Mo; $Mo + \frac{1}{2}\,\sigma_0$.

The effect of each kind of starch on strength and stretching capacity was determined graphically with considerable accuracy. The accuracy of the difference between values was established according to the principle that the difference between the values compared should be at least three times as great as its error. The error of the difference was calculated after the formula:

$$m\,o = \sqrt{m^2 + m^2}$$
$$\quad\;\; o$$

The following seven groups were established:

+ 3 — very great accuracy, above $M_0 + \frac{1}{2}\,\sigma_0$
+ 2 — above the mean, above Mo
+ 1 — above $Mo - \frac{1}{2}\,\sigma_0$
0 — nothing accurate
− 1 — below $Mo + \frac{1}{2}\,\sigma_0$
− 2 — below Mo
− 3 — below $Mo - \frac{1}{2}\,\sigma_0$

TABLE 3.—*Experimental impregnation of tissues with potato starch paste from different potato varieties and species*

Variety or Species	Number of Tests	Stretching Capacity (in Per cent)				Strength (in Gr. to a Thread)			
		M		m	Group	M		m	Group
Fabric without starch (check)	10	5.05	0.35	0.11	—3	261.4	14.8	4.7	—3
Technical starch	8	7.72	0.28	0.10	+1	298.8	22.2	7.8	0
S. andigenum v. *herrerae* Juz. et Buk.	7	7.54	0.64	0.24	0	293.7	13.3	5.0	0
S. andigenum v. quechuanum (Taccla) Buk. & Lech.	7	8.21	0.39	0.15	+3	291.6	8.2	3.1	0
S. rybinii Buk.	5	7.95	0.67	0.30	+1	304.2	18.1	8.1	0
Saami hybr. of I.A. and M. N. Veselovsky	8	7.59	0.42	0.15	+1	293.3	13.7	4.8	0
Katahdin	8	7.94	0.56	0.20	+1	303.0	14.8	5.2	+1
Khibin Bilberry	8	7.39	0.58	0.20	0	291.6	13.2	4.7	0
478/89 F_1 *S. andigenum* v. *herrerae* x Centifolia	10	7.15	0.46	0.15	—1	283.2	13.3	4.2	0
316/81 F_1 Fürstenkrone x *S. andigenum* Tocanum	8	7.53	0.60	0.21	0	288.4	13.1	4.6	0
Great Scot	8	7.37	0.50	0.18	0	275.0	13.6	4.8	—1
Witchill	8	7.34	0.48	0.17	0	286.7	17.1	6.0	0
Wohltmann	10	6.72	0.26	0.08	—3	284.7	15.6	4.9	0
Early Rose	10	6.65	0.52	0.16	—2	288.9	19.8	6.3	0
Snowflake	10	7.15	0.46	0.15	—1	284.3	12.0	3.8	0
Epicure	8	7.84	0.52	0.18	+1	288.3	9.7	3.4	0
Epron	9	7.47	0.23	0.08	+1	291.4	12.3	4.1	0
Popular (Narodny)	8	7.66	0.46	0.16	+1	281.8	23.2	8.2	0
Korenevsky	9	7.47	0.64	0.21	0	290.7	15.2	5.1	0
Hero	9	7.61	0.53	0.18	+1	302.7	20.8	6.9	0
	—	7.36	0.66	0.4	—	289.2	10.0	1.2	0

For the sake of convenience and clearness, it is better to make use of the graphic method when dividing into groups.

According to Professor S. D. Pomorsky's graphic method, the axis of the abscissae is drawn, and Mo — ½ σ_0 Mo, and Mo + ½ σ_0 are marked upon it with dots, from which straight lines are plotted in either direction at an angle, the tangent of which equals ⅓.

As seen from table 3, *S. rybinii* gives the greatest strength. The mean error (m) mathematically calculated is large because of the small number of tests, and for this reason this species falls into group 0. The next place is occupied by starch obtained from the variety Katahdin and is included in group + 1. None of the starches of the other sixteen varieties was outstanding in their adhesive properties. Starch from the variety Great Scot ranked last.

TABLE 4.—*Determination of paste percentage and stiffness*

Calico Samples Impregnated with Paste from Different Potato Starches	Paste per centage	Stiffness
Steeped in water	—	1.00
Wohltmann	4.12	1.73
Grenzmark	4.00	1.68
Khibin Bilberry*	3.38	1.63
Witchill	3.62	1.60
S. andigenum Juz. et Buk. v. *herrerae*	3.58	1.57
S. rybinii Buk.	3.53	1.56
Katahdin	3.63	1.50
Epron*	3.52	1.41

Hybrids of I. A. and M. N. Veselovsky's selection, see Appendix.

Starch from *S. andigenum* Juz. and Buk. v. *quechuanum* (Taccla) group + 3, was particularly prominent for the stretching capacity it gave to cloth fibres, second was *S. rybinii* Buk.; third Katahdin; fourth Epicure; fifth technical starch; sixth Popular (Narodny); seventh Hero; eighth Saami; and ninth, Epron. Particularly poor

results were obtained from Wohltmann and Early Rose. In every instance fabric not impregnated with starch was in the group 3.

The calico samples finished with the paste of various potato starches were dried in the open air for twenty-four hours. After drying, each strip of cloth was weighed and the percentage of paste was determined according to the difference between its weight before and after finishing. After drying and weighing, strips 15 cms. wide were cut lengthwise into two strips 6 and 9 cms. each. The 6 cm. strips were ironed and after being in the open air for 24 hours, were tested for stiffness on A. M. Mortorin's apparatus (Textile Institute). The 9 cm strips were subjected to tearing tests.

Conclusions

1. The qualitative composition of potato starch, *i. e.* the percentage of small and large grains should be considered a varietal characteristic.

2. The size of starch grains, for the most part, determines the quality of starch. Both small and large grain starches are of importance for industrial purposes.

3. In technological processes in the starch industry, large grain starch is easily separated, rapidly precipitated, and displays a fine lustre.

4. Large grain potato starch may be readily converted into a soluble starch particularly valuable as a component in warp sizing in the textile industry.

5. Small grain starch gives more viscous paste which plays an important part in the textile industry when used for finishing fabrics. When a starch is highly viscous, smaller amounts are used thereby effecting a saving.

6. Chemically pure potato starches from different species and varieties are not similar in their biochemical properties.

7. Some of the biochemical properties as ash content, phosphorus content and viscosity, are positively correlated, *i. e.* the higher the ash content, the more phosphorus and the greater the viscosity of the paste.

8. The highest viscosity was found in *S. andigenum* and its hybrids, the lowest in *S. rybinii,* Grenzmark, etc.

9. There has been established a direct relation between large size of starch grain and hydrolysing capacity, *i. e.* the larger the starch grains, the more rapid the hydrolysis. Distillers prefer those potato varieties that ferment most rapidly. Rapid hydrolysis and ease of the fermentation process are positively correlated in potatoes. Starches that hydrolyze readily are also of great interest to the food industries.

10. When considering the various ways potato starch may be made use of in the textile industry, one should bear in mind that, in the opinion of textile specialists, the warp sizing process requires starch possessing the lowest possible viscosity and readily penetrating into the outer parts of threads. Such starch is necessary to make the warp strong.

The potato species that approaches these demands nearest is *S. rybinii,* as its starch penetrates fabric readily.The same applies to the variety Grenzmark and others which approach *S. rybinii* in their biochemical properties.

On the contrary, the impregnation of fabrics with starch for the finishing process, requires a more viscous starch, extremely adhesive and with low hydrolytic capacity. The starch approaching these demands will be obtained from the hybrids of the Andean potatoes and varieties like Khibin Bilberry, Saami and Katahdin.

Our preliminary data have shown some biochemical differences in starches of various varieties and species, but this needs further investigation as also does their use as components in the sizing and finishing of fabrics.

Some forms with large grain starch will probably give a high grade of soluble starch suitable for first rate fabric sizing. There is no doubt that only starches of definite varieties should be used.

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Appendix

The Origin of the Potato Hybrids Selected by I. A. and M. N. Veselovsky

1. Kalitinetz. F_1 (Irish Cobbler x Fürstenkrone).
2. Epron. F_1 (Epicure x Alma).
3. Saami. F_1 (Early Rose x F_1 (*S. andigenum v. quechuanum* x Fürstenkrone).
4. Khibin Bilberry. F_1 (*S. andigenum f. tocanum* x Epicure) x Centifolia).
5. Umptek. F_1 (Early Rose x F_1 (*S. andigenum v. quechuanum* x Fürstenkrone).
6. Marnikve. F_1 (Epicure x (*S. andigenum f. Tocanum* x Centifolia).
7. Elf Umpteka. F_1 (Irish Cobbler x Jubel).
8. Polar Rose. F_1 (Early Rose x F_1 (*S. andigenum v. quechuanum* x Fürstenkrone).
9. Komsomoletz. F_1 (Irish Cobbler x Fürstenkrone).

PROGRAM OF THE TWENTY-SEVENTH ANNUAL MEETING OF THE POTATO ASSOCIATION OF AMERICA

December 29-31, 1940

President, C. H. METZGER, *Bakersville, California.*
Secretary, WILLIAM H. MARTIN, *Rutgers University, New Brunswick, N. J.*

Sunday, December 29, 2:00 P. M.; Mezzanine Floor, Hotel Philadelphian. The American Phytopathological Society, Plant Disease Demonstration Session. Included in this demonstration session will be an exhibit of the results of potato breeding investigations for resistance to scab arranged by F. J. Stevenson.

Monday Morning Session, December 30, 9:15 A. M.; Room 313, Engineering Building, University of Pennsylvania.

1. Report of the Secretary-Treasurer, Editor.

2. Appointment of Committees.

3. *Report of the Seed Certification Committee.* (15 min.) MARX KOEHNKE, Alliance, Nebraska.

4. Report of Committee on Nomenclature. C. F. CLARK, U. S. Department of Agriculture, Beltsville, Maryland.

5. *Factors Affecting the Marketability of Ohio Potatoes.* (20 min.) (Lantern) E. B. TUSSING and C. W. HAUCK, Ohio State University, Columbus, Ohio.

6. *Factors Influencing the Cracking of Late Crop Tubers at Harvest Time.* (20 min.) (Lantern) H. W. WERNER and J. O. DUTT, University of Nebraska, Lincoln, Nebraska.

7. *Some Possibilities of the Fall Crop of Irish Potato in North Alabama.* (10 min.) L. M. WARE and H. M. DARLING, Alabama Polytechnic Institute, Auburn, Alabama.

8. *Bordo Spray Gains in Iowa.* (10 min.) C. L. FITCH, Iowa State College of Agriculture, Ames, Iowa.

9. *Effect of Different Amounts of Leaf Roll and Spindle Tuber on Yield in Potatoes.* (10 min.) H. A. JONES, U. S. Department of Agriculture, Beltsville, Maryland.

10. *Inheritance of Resistance and Susceptibilty to Hopper-Burn in the Potato.* (10 min.) (Lantern) J. P. SLEESMAN and F. J. STEVENSON, U. S. Department of Agriculture, Beltsville, Maryland.

11. *Potato Virus Investigations in* 1940. T. P. DYKSTRA, U. S. Department of Agriculture, Beltsville, Maryland.

12. *Report of Committee to Coordinate Research on New and Unusual Potato Diseases.* J. G. LEACH, West Virginia University, Morgantown, West Virginia.

13. *Varietal Susceptibility of Potatoes to Fusarium Wilt.* (15 min.) (Lantern) R. W. GOSS and J. H. JENSEN, University of Nebraska, Lincoln, Nebraska.

14. *A Method of Selecting for Fusarium Resistance in First-Year Potato Seedlings.* (15 min.) (Lantern) J. H. JENSEN and R. W. GOSS, University of Nebraska, Lincoln, Nebraska.

Monday Afternoon Joint Session with American Society for Horticultural Science, December 30, 2:00 P. M.; Room 326, Engineering Building, University of Pennsylvania.

E. V. HARDENBURG, *Chairman*

1. *Potato Quality III. Relation of Soil Reaction, Irrigation, Fertilizers and Rotation Systems to Culinary Quality.* (12 min.) (Lantern) ORA SMITH and L. B. NASH, Cornell University, Ithaca, New York.

2. *Potato Quality IV. Relation of Variety and Environmental Condition to Partial Composition and Cooking Quality.* (12 min.) (Lantern) L. B. NASH, Cornell University, Ithaca, New York.

3. *Environmental Factors Affecting Tuberization in the Wild Potato, S. demissum.* (10 min.) G. E. DAVIS. Cornell University, Ithaca, New York.

4. *Effect of Length of Day on the Growth Characters of the Irish Potato Tuber, Its Vegetative Growth, and Maturity.* (10 min.) (Lantern) JULIAN C. MILLER and FRED McGOLDRICK, Louisiana State University, University, Louisiana.

5. *Effect of Spraying with a Naphthalene Acetamide and Other Factors Affecting Seed-Setting in Potatoes.* (10 min.) A. E. CLARK, W. C. EDMUNDSON, and P. M. LOMBARD, U. S. Horticultural Station, Beltsville, Maryland.

6. *Morphological Response of Strains and Varieties of Potatoes to Controlled Environments Simulating Northern and Southern Conditions.* (10 min.) (Lantern) H. O. WERNER, University of Nebraska, Lincoln, Nebraska.

7. *The Classification of American Potato Varieties.* (20 min.) (Lantern) C. F. CLARK and P. M. LOMBARD, U. S. Horticultural Station, Beltsville, Maryland.

8. *Effect of Differential Fertilizer Placement in the Production of Potatoes on Long Island.* (15 min.) (Lantern) R. H. WHITE-STEVENS and P. H. WESSELS, Cornell University, Ithaca, New York.

9. *Factorial Design Experiments with Potatoes.* (15 min.) (Lantern) ORA SMITH, FRED McGOLDRICK and G. E. DAVIS, Cornell University, Ithaca, New York.

10. *Maintenance of Adequate Aeration for Potatoes in Silt Loam.* (10 min.). (Lantern) JOHN BUSHNELL, Agricultural Experiment Station, Wooster, Ohio.

11. *A Rare Abnormality in Stored Potato Tubers.* (5 min.) (Lantern) E. V. HARDENBURG, Cornell University, Ithaca, New York.

Tuesday Morning Session, December 31, 9:00 A. M. Regular Session; Room 313, Engineering Building, University of Pennsylvania.

1. Report of Committees.

2. *Potato Insect Investigations in* 1940. W. A. RAWLINS, Cornell University, Ithaca, New York.

3. *Potato Culture and Storage Investigations in* 1940. E. V. HARDENBURG, Cornell University, Ithaca, New York.

4. *Potato Fertilizer and Nutrition Studies in* 1940. ORA SMITH, Cornell University, Ithaca, New York.

5. *Relation of Light Intensity and Length of Photoperiod to the Production of Flowers and Berries by Several Varieties of Potatoes in the Greenhouse.* (10 min.) (Lantern) H. O. WERNER, University of Nebraska, Lincoln, Nebraska.

6. *The Influence of Fertilizers on Potato Tuber Shape.* (10 min.) K. C. WESTOVER, West Virginia University, Morgantown, West Virginia.

7. *Effect of Potash, Lime and Manure Applications on Yields of Potatoes.* (12 min.) (Lantern) ORA SMITH and FRED McGOLDRICK, Cornell University, Ithaca, New York.

8. *Relation of Soil Reaction and Green Manure to Yield and Quality of Potatoes.* (12 min.) (Lantern) ORA SMITH and G. E. DAVIS, Cornell University, Ithaca, New York.

9. *The Influence of Split Applications of Complete Fertilizer on the Yield of Irish Potatoes.* (10 min.) E. P. BRASHER, West Virginia University, Morgantown, West Virginia.

10. *Minor Element Studies on Potatoes in Maine.* (15 min.) ARTHUR HAWKINS, JOSEPH H. CHUCKA, B. E. BROWN, Maine Agricultural Experiment Station, Orono, Maine.

11. *Results of Attempted Eradication of Bacterial Ring Rot from Potatoes.* (10 min.) DUDLEY PETERS GLICK, Colorado Experiment Station, Fort Collins, Colorado.

12. *The Use of the Ultra Violet Lamp in Ring Rot Control.* (10 min.) F. M. HARRINGTON, V. E. IVERSON, and H. C. KELLY, Agricutural Experiment Station, Bozeman, Montana.

Tuesday Afternoon, Joint Session with the American Phytopathological Society, December 31, 1:30 P. M.; Ball Room, Hotel Philadelphian.

J. G. LEACH, *Chairman*

1. *The Role of Insects in the Pit Scab of Potatoes.* (15 min.) (Lantern) A. A. GRANOVSKY and A. G. PETERSON, University of Minnesota, St. Paul, Minnesota.

2. *A Method of Determining Loss in Yield Caused by Diseased or Missing Plants and Trials with Leaf Roll of Potatoes.* (10 min.) (Lantern) F. M. BLODGETT, PHARES DECKER and C. S. TUTHILL, Cornell University, Ithaca, New York.

3. *The Incidence of Purple Top Wilt in Pennsylvania on Certain Potato Varieties.* (7 min.) (Lantern) C. D. BURKE, Pennsylvania State College, State College, Pa.

4. *Potato Ring Rot Studies in California.* (15 min.) (Lantern) J. B. HENDRICK, University of California, Davis, California; P. A. ARK and C. EMLEN SCOTT, University of California, Berkeley, California.

5. *Bactericidal Efficiency of Sodium Hypochlorite and Other Chemicals against Phytomonas sepedonicum.* (10 min.) (Lantern) WILLIAM W. DORRELL, E. A. MARTEN and J. G. LEACH, West Virginia University, Morgantown, West Virginia.

6. *Fluorescence of Potatoes under Ultraviolet Light for Detecting Ring Rot.* (10 min.) (Lantern) R. B. HARVEY, University of Minnesota, St. Paul, Minnesota.

7. *Ring Rot Symposium.* Discussion Leader: T. P. DYKSTRA, U. S. Department of Agriculture, Beltsville, Maryland.

REPORT OF THE TWENTY-SIXTH ANNUAL MEETING OF THE POTATO ASSOCIATION OF AMERICA

The Twenty-Sixth Annual Meeting of the Potato Association of America was held at Columbus, Ohio. Sessions were held in Page Hall, Ohio State University, the joint sessions with the American Society for Horticultural Science in Horticultural Hall, and the American Phytopathological Society in Page Hall. There were forty papers and reports presented and all the sessions were well attended.

Officers and Committees

President, C. H. Metzger, Colorado State College, Fort Collins, Colorado

Vice-President, F. M. Blodgett, Cornell University, Ithaca, N. Y.

Secretary-Treasurer-Editor, Wm. H. Martin, N. J. Agricultural Experiment Station, New Brunswick, N. J.

Executive Committee—Ora Smith, Ithaca, N. Y.; L. M. Ware, Auburn, Alabama; R. A. Jehle, College Park, Maryland; A. H. Eddins, Hastings, Florida

Certification Committee—R. J. Haskell, U. S. Department of Agriculture, Washington, D. C.; A. H. Eddins, Hastings, Florida; R. R. Pailthorp, Washington, D. C.; E. L. Newdick, Augusta, Maine; A. G. Tolaas, St. Paul, Minn.; H. M. Darling, Fairhope, Alabama; G. H. Starr, Laramie, Wyoming; J. G. Richard, University, Louisiana; Marx Koehnke, *Chairman,* Alliance, Nebraska

Committee on Standardization of Field Plot Technique—J. R. Livermore, Ithaca, N. Y.; H. O. Werner, Lincoln, Nebraska

Committee on Potato Consumption and Dietetic Value—C. H. Metzger, *Chairman;* E. J. Wheeler, C. R. Fellers

Committee to Coordinate Research on New and Unusual Potato Diseases—J. G. Leach, *Chairman;* T. P. Dykstra, R. W. Goss

Potato Variety Nomenclature Committee—C. F. Clark, *Chairman,* U. S. D. A.; C. H. Metzger, Fort Collins, Colorado; J. C. Miller, Baton Rouge, Louisiana; Wm. Stuart, Washington, D. C.; E. V. Hardenburg, Ithaca, N. Y.

Potato Breeding Work in 1939—F. J. Stevenson, U. S. Department of Agriculture

Cultural and Storage—E. V. Hardenburg, Ithaca, N. Y.
Fertilizer Investigations—Ora Smith, Ithaca, N. Y.
Virus Diseases—T. P. Dykstra, U. S. Department of Agriculture
Potato Insects—W. A. Rawlins, Ithaca, N. Y.

The following committees were appointed to serve throughout the meetings:

Resolutions Committee—Reiner Bonde, Karl H. Fernow, C. L. Fitch
Nominating Committee—E. L. Newdick, T. E. Odland, John Bushnell
Auditing Committee—F. R. Krantz, E. J. Wheeler, John Tucker

Report of the Secretary-Treasurer

The membership of the Association is now 1565 as compared with 1214 in 1938; 1293 in 1937, 1114 in 1936 and 812, in 1935. It is gratifying to note that the association continues to grow, although very slowly. It should be pointed out that a considerable part of the increase in membership this year resulted from the fact that the Utah Potato Association subscribed for 178 members. It would mean much to the association if all the various state organizations would adopt this plan, which is now being followed by four states; New Jersey, New York, Utah and Washington. It is of interest to note that we now have 35 subscribers in Canada; 75 in Europe; and 14 in South America. In this country our members reside in 45 states.

This year the Journal contained 338½ pages of printed and 71¼ pages of advertising matter. Certain of our advertisers continue to support the Journal and there is every reason to believe that others could be interested, since it is read by leading potato growers in all the important potato-growing sections.

Statement for the Year Ending December 21, 1939

Receipts

Balance Dec. 21, 1938	$18.45
Annual Dues	1,463.07
Sale of Advertising	1,288.73
Reprint Receipts	316.32
Miscellaneous	68.08
Received from Michigan Bank on Account	49.51
TOTAL RECEIPTS	$3,204.16

Expenditures

Printing and Mailing of Journals (September, 1938, to September, 1939, incl.)	$2,120.50
Reprints	216.89
Miscellaneous	22.42
Secretarial Work	335.00
Stenographic Services	274.80
Stamps and Supplies	163.96
TOTAL EXPENDITURES	$3,133.57
BANK BAL. DEC. 21, 1939	$70.59

Accounts Receivable

Reprints	$25.30
Miscellaneous	18.50
Michigan Bank	52.43
Advertising	30.00
Back Issues	56.82
TOTAL ACCOUNTS RECEIVABLE	$183.05

Accounts Payable

October issue	$152.88
November issue	168.29
Reprints and Supplies	65.25

Report of the Auditing Committee

We, the undersigned auditing committee, have examined the books of the Potato Association of America and have found them to be in good order.

F. A. KRANTZ, *Chairman*
E. J. WHEELER
JOHN TUCKER

Report of Committee on Resolutions

1. We the members of the Potato Association of America, at our

twenty-sixth annual meeting, wish to express our appreciation to Ohio State University for the facilities and the many courtesies shown us.

2. We wish to thank our own secretary for his highly skilled and persistent service.

3. We express our appreciation to Dr. Elizabeth S. Clark for her zealous correctness in the editing of our papers.

4. We advocate, for the long time interest of the potato industry, that high table quality be given special emphasis, in the introduction and promotion of new varieties of potatoes.

REINER BONDE
KARL H. FERNOW
C. L. FITCH, *Chairman*

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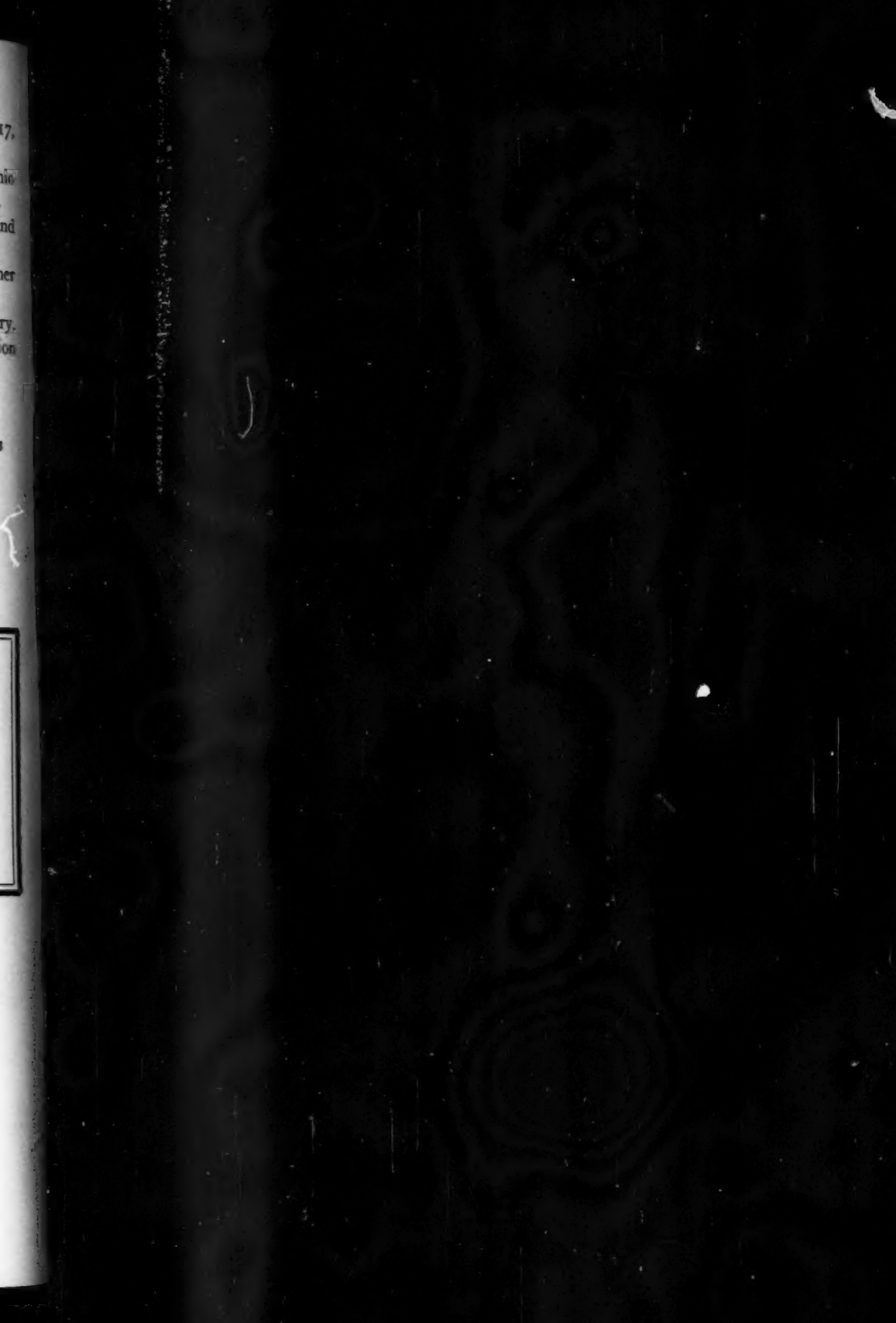
The responsible marketing agency of the best seed potato growers in New York